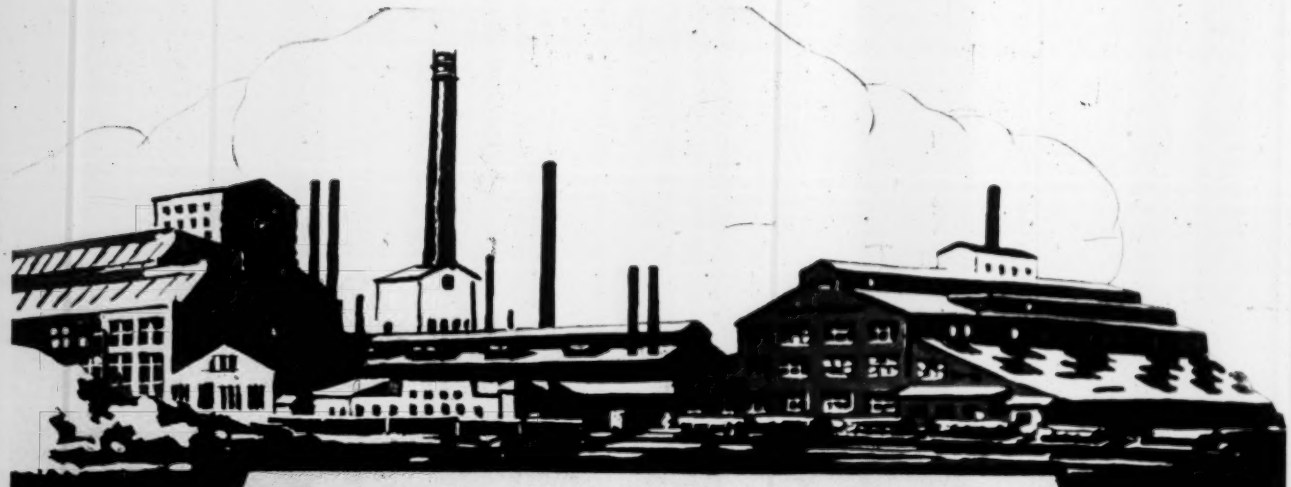

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Greetings to New Members

YOU have been admitted to a great fraternity of 18,000 brothers and a few sisters, in which you are to find your place and take a part. We welcome you among us and congratulate you on your choice of a calling. But, let us ask, what was your object in seeking this alliance?

Was it for the thrill of marching in step with a great throng? Was it the hope of personal advancement? Was it to widen your horizon and increase your knowledge in your line of engineering?

We presume that some or all of these motives were more or less clearly in your mind, and they are all worthy motives; and yet, if they and their kind constitute all of the reasons you had for seeking membership with us, you and we will be disappointed with each other; you have forgotten the foundation stone of the column—service.

We had hoped and we believe that by this affiliation you expected to better serve yourself, your employer, your fellows, your profession, and your fellow-man. We hope that you are willing to serve your client—for a fee, yes, but willing to serve society without one; willing to help a brother engineer; willing to give of your strength, time, and talents to improve the standing of the engineering profession, and to make contributions to the sciences with which you have some acquaintance; and willing to take a citizen's part in the consideration and solution of the civic questions interesting your community.

You have chosen and have prepared yourself for a calling that will guarantee you a living—usually a competence, but seldom more. High though your engineering achievements, valuable and lasting as those contributions may be to the welfare of your fellow-man, praise, honors, wealth, or other commensurate recognition will not be yours.

You have been set apart for service, not in a temple but in the broad and practical field of material things—a field of romance and adventure, of discovery and conquest, where the frontier ever recedes and never ends; where victories spell the defeat of no foeman, and gains are no competitor's loss. What is created is added to the world's wealth, and what is discovered is added to the world's knowledge.

Take your place in our ranks, and although the world you serve so well accepts your gifts with scant recognition to the giver, you still have recompense in the fascination of your work, the satisfaction of creating, and the joy of serving.

W. L. ABBOTT.

MECHANICAL ENGINEERING

Volume 50 January, 1928 No. 1

Human Engineering[1]

By CHARLES M. SCHWAB, NEW YORK, N. Y.

OF ALL the arts and crafts and professions to which men devote their energy and their talents, none more profoundly affects the destiny of the human race than engineering. From the Pyramids of Egypt to the Panama Canal and present-day achievements in conquering time and space, the profession of the engineer has played a dominant part in the lives of men and nations. It has chosen the ablest, the most daring, and the most energetic of men, has inspired them with the desire for achievement, and has then exacted their utmost of devotion and service. It is but natural that the result has been measured in better and higher standards for society. Wherever engineering has excelled, there we find the highest order of life.

In their progress during the last half century, engineering and industry have marched side by side. Their development is a remarkable story of scientific achievement. The mobilization of capital and engineering talent has made possible the large-scale industry that is the leading characteristic of the wonderful era of progress in which we live.

CHARLES M. SCHWAB

HUMAN PROBLEMS IN AN INDUSTRIAL CIVILIZATION

This new industrial order created its own problems—new problems of social and economic aspect requiring the highest type of statesmanlike management for their solution. Industry has brought together and welded into single organizations hundreds, sometimes thousands, of human beings with widely different habits of life and thought. For the success and happiness of these human beings and of society as a whole, it is vitally important that mutual relationships should be adjusted on the basis of fair dealing and cooperation. Here is a problem embodying the recognition of all the differing physical and mental characteristics of individual human beings, and one peculiarly within the province of the engineer, which includes all industrial benefits to mankind.

Need for the solution of this problem brought forth a new concept of the management of business. At the same time it created a new science, a new field of engineering which, for want of a better name, we call human engineering—the practical science of humanizing industry and of making the men in it substantial, self-respecting workmen and citizens and factors cooperating in the success of the business. This new science recognizes that industry is dependent upon mass production, machine processes, and technical skill, but that the human element after all determines the progress of a business and its service to the country at large.

CONFLICTS IN INDUSTRY RUINOUS TO ALL PARTIES

Forward-looking management, as well as far-sighted representatives of employees, are coming to realize that if full benefits are to be had from the creations of engineers, industry must be viewed as a cooperative undertaking, in the advancement of which every supervisor and every employee is an important factor. They recognize that conflict between capital and labor is destructive of the interests of each; that it is unnecessary and mutually expensive.

Herein lies a field where expert service in enlisting the interest and confidence and good-will of the workers becomes just as important as the study that has been given to the characteristics and utilization of materials. Out of its solution comes a new code of economics, a code that aims not only to provide food and clothing and shelter, but also to elevate society at large and to place a true dignity upon labor, a dignity that yields a fuller and happier measure of life. It is highly fitting that we in America have led the way to better industrial relations, for indeed there is being brought forward a truer realization of the principles set forth in that great document signed at the inception of our nation enunciating the doctrine that among the unalienable rights of men are life, liberty, and the pursuit of happiness.

But this happiness does not lie along the road of abolishing work, for work is the cornerstone of real happiness. It lies in the doing of the day's work with a zest and good-will, under the spur of encouragement and rewarded with the satisfaction of achievement. This requires the cooperation of labor itself,

[1] Presidential Address at the Annual Meeting, New York, N. Y., December 5 to 8, 1927, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

not merely of the hand but of the heart as well. To obtain that cooperation requires leadership in industry that regards itself not as partisan but as a trustee striving to guide the efforts of both capital and labor into profitable channels.

Responsibility of Engineers in Human Relations

One cannot reflect on the subject of human engineering without realizing the tremendous responsibility that rests upon management in guiding the destiny of mankind. Indeed we are impressed that the solution of this problem holds out a challenge to industrial statesmanship that is of paramount importance to the prosperity of our nation. It is a tribute to American industrial management that these principles have largely been recognized, and that in this country today the parties to industry generally recognize their responsibilities and opportunities.

In this human achievement, which is outstanding in the present era, the engineer has played a dominant part, for he has often played the role of manager too. It is highly proper that his efforts should be recognized. I can think of no more fitting illustration of the recognition of his contribution than the recent honor accorded a brother engineer, Mr. Eugene G. Grace, on the occasion of the award to him by one of our great universities of the degree of Doctor of Engineering. I cite this incident because of the peculiar personal satisfaction which it gave me, and because in presenting him for the degree the eminent educator paid a tribute to our whole engineering profession when he said:

> Mr. Grace was one of the first American business leaders to rise to the opportunity of bringing about better relations between employer and employee. By his vision and example in dealing with these hitherto unsolved economic and social problems he brought forth a new management in industry.
>
> Mr. Grace is not merely the executive head of the greatest independent steel corporation in the country, but has had from the beginning a profound acquaintance with the intricate technology of steel-making. As a student of economics he was able to appreciate that large production could be followed by high wages, and had the engineering skill to see that these benefits to his fellow men could be brought about by making the greatest use of electrical power in manufacturing processes.
>
> It is not, however, the stupendous growth in the physical plant nor the mere mastering of machine production on which rests Mr. Grace's reputation as a captain of industry. Though less spectacular, his pioneer work in Human Engineering—the practical science of humanizing industry—is perhaps his most outstanding achievement.

Efforts of Engineers and Managers to Solve Capital-Labor Problem

From the problem growing out of employer-employee relationships in modern large-scale industry, let us turn now to the efforts at solution that have been made by engineers and managers in responsible control of business enterprises. In dealing concretely with this part of the subject, I hope I may be pardoned for drawing illustrations largely from the experiences of the Bethlehem Steel Corporation, which is only one of many industrial concerns that in recent years have taken advanced positions in this vitally important subject.

Our job primarily is to make steel, but it is being made under a system which must be justified. If in addition to manufacturing products this system does not enable men to live on an increasingly higher plane, if it does not allow them to fulfil their desires and satisfy their reasonable wants, then it is natural that the system itself should fail.

Reasonable Wants of Industrial Workers

What are these reasonable wants of employees, which they have a right to see satisfied as far as conditions of industry permit? I believe they include the payment of fair wages for efficient services; steady, uninterrupted employment; safeguarding of their lives and health, good physical working conditions; a voice in the regulation of conditions under which they work; provision for them to lay up savings and to become partners in the business through stock ownership; and finally, some guarantee of financial independence in old age.

Modern Management and the Fundamental Question of Wages

The desire of labor in connection with wages can, I believe, best be fulfilled by rewarding men in accordance with their contributions toward the success of the business. It is fundamental with human beings that they want individual recognition of and reward for their talents and achievements. This is the crux of the wage problem. The nearer we can come to fulfilling this want on a sound, justifiable basis that recognizes individual merit, the sooner shall we witness the solving of a long-standing and contentious question.

Relations in industry have sometimes become strained over the fundamental question of wages. The area of conflict was widened because of adherence to a policy which sought to group together at a uniform wage, regardless of individual performance, large bodies of workers even though geographically widely separated. Such a policy often tended to discourage effort and to reduce individual output to a standard set by the least efficient worker.

We have traveled far in our thinking on this fundamental question of reward for service. We have come to have a new viewpoint toward the payment of wages. Our better relationships have brought a clearer understanding of the reciprocal value to national well-being of a class of well-paid workers whose buying power is sufficient to take the output of our mass production. We are ambitious to see our workers receive an adequate wage—a wage that is sufficient to afford a worker and his family a decent standard of living with a margin for laying something aside—but we cannot entertain any uneconomic theories as to doles or subsidies. We cannot lose sight of the fundamental law that requires full value in services for wages paid.

How to measure and relate output and wages on some fair basis has become an important function of management. We now realize the essential benefits derived from relating compensation to the contribution made by the individual, with the result that under the stimulus of measured return for service rendered there is an increasing tendency for men to take a keener interest in the business, much as if they owned it. This applies to workers as well as managers.

Economic Status of American Wage Earners

The economic position of our workers has become the wonder of the world. The earnings of American wage earners in terms of what they can buy are probably greater now than at any previous period in American history; certainly they are far greater than those of the workingmen in any other country of the world. In the face of these higher earnings our foreign brothers marvel at the coincidence of lower costs. The answer is that American workmen have come to realize that wages and profits are paid out of the same pocketbook and that the return to each must be proportionate to effort expended. American workmen are responding to the bid that is being made for their cooperation and realize the important factor they are in the success of the business, and they appreciate that their employers under an enlightened human-relations policy are striving to provide as high wages as can be paid consistent with sound management and the safeguarding of the investment and in line with general economic conditions.

STEADY EMPLOYMENT

High wages do no good to the man who has no chance to earn them. Hourly and daily rates mean little to the employee who can work only a few days a month or a few months out of the year. Steady employment, therefore, ranks high among the needs of the workman. During the last few years industrial managers have been giving much thought to this question—to the elimination of the evil of unemployment. It has come to be realized that peaks and valleys of industrial activity, during which periods of feverish effort to get out products alternate with periods of idleness and stagnation, not only are undesirable from the standpoint of the workingman but are wasteful and expensive to industry and to society as a whole. Toward the leveling of these peaks and valleys much has been done by the intelligent efforts of management; perhaps even more has been accomplished as a result of the sustained purchasing power built upon high wages and of the changed buying methods of the public. This last-named element, in turn, has resulted largely from the increased capacity and reliability of both production and transportation. Thus we see the interdependence of all the elements in that intricate machine we call industry.

The records of our own company illustrate the substantial progress which has been made in reducing these peaks and valleys. Whereas the high and low points of employment a few years ago fluctuated fifty per cent from the average, during the following years these fluctuations were steadily reduced until in 1926 the high and low points of employment as measured by the payroll varied hardly eight per cent from the average for the year. This regularity of work is not only of vital importance to employees but it has a far-reaching influence on good business.

FINANCIAL INTEREST IN THE BUSINESS

But even with good wages and steady employment, the workingman is likely to lack one factor essential to his fullest efficiency and greatest interest in the company by which he is employed. This factor is ownership. A sense of proprietorship affords a powerful incentive to arouse interest in the performance of work. This principle has been the motivating influence of those who have been willing to take the risk incident to the building of all business. Its application to the wage earner in industry is relatively new, yet nowhere is the whole-hearted interest of human beings so necessary and vital to successful accomplishment. Recent years have seen a considerable growth in stock ownership by industrial employees. I would not minimize the possibilities of danger involved in this practice, nor would I urge every company, regardless of the character of its securities, to enlist its wage earners as partners. Under favorable circumstances, however, and with the proper safeguards against speculation and possible loss, stock ownership by employees may be one of the most successful incentives to thrift and to vital interest in the enterprise. We are greatly encouraged with the results of our own experience along this line. In our efforts to increase the interest of our employees in the business and at the same time to afford them a means of saving and investment, Bethlehem has for several years encouraged the employees to acquire ownership through the Employees' Saving and Stock Ownership Plan.

That they have enthusiastically responded to this opportunity is shown by the fact that in the short period of four years over fifty per cent of our employees have either paid or are paying for substantially seventeen per cent of the corporation's stock of this class outstanding, representing an investment at par value of $17,000,000.

It is gratifying and highly significant as reflecting the present economic position of the workers that their wages have permitted them to make such substantial savings, but it is equally significant that they now have become capitalists with a financial interest in the business.

Under a plan of this kind the mutuality of interest which should exist in industry finds its greatest expression. On the one hand the company prospers because the employees strive for the elimination of waste and the better doing of their jobs, and on the other hand the employees themselves profit as the company prospers.

COOPERATION THROUGH REPRESENTATION PLAN

Successful human relations in industry recognize that the interests of employees and employers are mutual. It is recognized that as enemies they cannot long endure; they must be friends. The very nature of their aim for profit creates an interest in one another's well-being.

It is true that just as in any human relationships there are day-by-day problems arising in industrial relations which, if not settled with full justice to each, will threaten this bond of friendship. But the need for a medium for preventing or adjusting breaches in relations is not the whole objective of employees and employers. Essentially these two parties have been seeking a medium that would provide a common meeting ground. They have really been seeking for a way of living together which would permit an expression of their personality and yet cement and increase this friendship. The employee-representation movement is such a constructive medium, permitting not only settlement of questions on which there is a conflict of interest, but, of even more importance, offering an unobstructed channel through which their unity of interest may be promoted.

The cornerstone of Bethlehem's relations with its employees, in so far as their direct contact with the company in their daily job is concerned, is the employees' representation plan which was inaugurated nine years ago. To this plan and to good faith in living up to its provisions is to be attributed much of the gain in cooperation and good-will which we enjoy in our internal relationships.

Our company was one of the first to inaugurate employee representation in its plants, and in the early stages of the plan there was a natural tendency to lay the greatest emphasis upon its possibilities as a mechanism for grievance adjustment. Experience has shown, however, that this phase of its operation is giving way more and more to constructive efforts to improve conditions in the business and to constructive cooperation along the lines of increased efficiency, elimination of waste, and improved methods and quality and quantity of products. Along with this development has come a growth in morale and in sympathy and understanding between the employees and the officials. On the one hand the employees have gained a more intimate knowledge of their company and its objectives, and, on the other hand the supervisors have come to realize more definitely than before their function as leaders rather than as drivers of men.

HOW THE REPRESENTATION PLAN WORKS

The plan, in its essentials, provides for the election by ballot of representatives by and from among the employees. It has for its purpose four fundamentals: to give the employees a voice in the determination of the conditions under which they work, to promote cooperation between employees and management in matters of efficiency and economy, to furnish machinery for the prevention and adjustment of differences, and, so far as possible. to provide and foster continuous employment.

The plan is primarily a system which provides for election by shops or departments of representatives to meet and deal with the management for the discussion, regulation, and adjustment of matters having to do with all the conditions which may

arise out of employment. Nominations and elections are held annually in each plant by secret ballot, and are conducted by the employees themselves with only such assistance from the management as may be required.

The annual elections give an indication of the interest of the employees in this plan. The average percentage of eligible employees voting last year at the different plants was 93 per cent. Between 1918 and 1926 this percentage rose from 60 per cent to the present figure.

All action taken under the plan is joint action, and regular meetings are held with management representatives to discuss and pass upon questions that may arise.

Each employee representative is guaranteed full independence of action, and Bethlehem accepts the policy of arbitration. In other words, if no satisfactory adjustment of the case is reached, it may be left to arbitration. In no case, however, during the past nine years has it been necessary for any case to go to arbitration.

Annual Conferences with Employees

One of the striking developments of this whole system, and one which represents in our judgment a far-reaching step, is a series of annual conferences at the various plants of the corporation. One of the objects of these conferences has been to make an annual report to employees just as the corporation makes an annual report to its stockholders. At these meetings the employee representatives and management representatives sit down with Mr. Grace, the president of the company, and other executive officers for the consideration and discussion not only of employee matters, but of general business conditions and questions of company policy.

At this year's conferences, which were concluded a few months ago, I had the opportunity to join in these proceedings, and nothing could indicate to me more clearly than these meetings the fact that over the last few years real progress had been made in better industrial relations and that such cooperative activities as I have mentioned lead to constructive endeavor on the part of both management and employees and to material benefits to all concerned. At these conferences all subjects relating to employees and their welfare are discussed, the company executives report on the state of business and the outlook for the year as it may affect wages, working conditions, and the volume of product, and the employees present their point of view on their activities, on the steel business, and on plant operations. The officer in charge of industrial relations makes a report on the operation of all employee activities, and the president himself discusses in a most intimate manner all phases of the corporation's business. Suggestions are freely made and openly debated. The result is that both management and men get an insight into what each other is thinking and an understanding of the other fellow's point of view, which cannot but be effective toward advancing the interests of all.

Safeguarding Life and Health

With high wages, steady employment, a financial interest in the business, and a means of contact and cooperation with the management through representatives of his own choosing, the wage earner has perhaps secured the fulfilment of the most important and vital of his desires. There are other factors in industrial relations, however, which should by no means be overlooked. One of these concerns the safety of work and the provision made for the employee in the event of sickness or accident. For indeed both sickness and accident affect both wages and stability of employment.

Advances made in industrial-safety work since the beginning of the century have been noteworthy and reflect credit alike upon management and men, for essentially it has been a cooperative movement. Much of this advancement has been due directly to the efforts of the larger industrial corporations. One of the things for which the world will long remember my friend, the late Judge Gary, was his continued and successful effort to improve safety conditions in the great industrial organization of which he was for so many years the head.

Bethlehem carries on a thoroughly organized and persistent campaign of accident prevention, first-aid instruction, and safety work. Permanent safety committees consisting of employees of various operating departments are charged with the duty of cooperating with their immediate supervisors in maintaining maximum safety of working conditions, and they receive additional compensation for this service. One of the features of the first-aid work carried on under the guidance of competent doctors and nurses is a meet at which first-aid teams from various plants compete for substantial cash prizes. Since the beginning of this work more than 8000 of our employees have received first-aid instruction.

To assist the employee in case of sickness or death, the corporation has a relief plan which covers all employees. Its purpose is twofold: first, to provide disability benefits when their income is cut off because of sickness or accident not provided for by law, and second, to provide death benefits for the widows and dependents of employees. Funds for the payment of benefits are derived from contributions by the employees and from contributions by the corporation, the corporation assuming all administrative expenses.

The administration of this plan is typical of Bethlehem's policy of joint management of affairs directly affecting the employees. Questions of general policy, amendments, changes, and problems arising under the plan are determined by a board of trustees, half of whom are chosen by the employees and half by the management. The amount paid out yearly in benefits under this plan is nearly $1,000,000, and substantially all eligible employees throughout the corporation have become participants in it.

The company also maintains a well-organized medical service in each of its plants for the convenience of the employees, in the belief that sympathetic understanding on the part of the plant doctor is of equal importance to technical skill and that the medical department contributes a great deal toward providing steady work. As a result of all this effort we have reduced preventable accidents nearly sixty per cent in the last eleven years. Here is another example of a worthy contribution through cooperation toward a better day in industry with the result that there is a return to the employee in a physical and monetary saving, a return to the employer in lower costs, and a return to the community through a lessening of care for the maimed and disabled.

Provision for Support in Old Age

One of the most difficult problems not only in industry but in society as a whole is the maintenance of those who on account of old age are no longer able to support themselves. Many industrial companies have recognized an obligation in this matter and are seeking to provide for their aged employees through various types of pensions. To meet the economic needs of the aged worker, however, is not the only aim of a pension plan; it also provides a highly fitting basis for rewarding those faithful workers who have given their best years in the service of the company.

Bethlehem has a pension plan under which an employee who has reached the age of 65 and has rendered 25 years of service may retire on a pension. There are today under this plan more than 1000 former Bethlehem employees who, while not rendering active service to the company, are nevertheless as whole-heartedly

interested as ever in its success. Ours is one of the newer pension plans, having been established only about five years ago, but already there is being paid out to pensioners nearly one-half million dollars a year.

AID TOWARD HOME OWNERSHIP

The present tendency of workers to invest in the purchase of what are regarded by some as luxuries is sometimes viewed with concern. On the whole I believe this tendency is but a step in the march of progress to a higher standard of life—a fulfilment of the new code of economics under which the luxuries of yesterday are becoming the necessities of today. Fundamentally the whole trend is based upon the better economic position of the worker helping to place these conveniences within the reach of all. Workers will acquire them in accordance with their economic ability and to suit their individual tastes. They will make their own decisions as to their individual needs, and will not require any special assistance in doing so.

But in the desire for home ownership, which ranks high among the ambitions of the average workman, there is generally need for financial assistance. We believe that any assistance we can render our employees to help them realize this desirable ambition not only makes for better standards for them, but makes for a better community as well.

With this in mind Bethlehem for several years has had a plan under which the company helps its employees purchase homes on easy partial payments. The company has thus assisted employees to build or buy homes valued at several millions of dollars. Its aid in this housing program takes the form mainly of guaranteeing or purchasing the second mortgage on the property. The employee has the advantage of advice from the company's architectural, engineering, financial, and legal departments. He receives full title to the property, is under no obligation to the company so long as monthly payments on the mortgage are kept up, and his dependents are protected in the event of his death by a life-insurance policy at low rates during the terms of his indebtedness.

MEASURING BENEFITS OF HUMAN ENGINEERING

If I have seemed to give undue prominence to the human-engineering program of the Bethlehem Steel Corporation, it has been done merely in order to illustrate the general tendency of large-scale industry by concrete facts drawn from the organization with which naturally I am most familiar. Industry as a whole, and particularly that part of it to which the term "big business" has been applied, has made important progress along this line of bringing justice and cooperation between employers and employees.

Naturally, such an ambitious program has not been put through without expense, but we do not believe that this money is being used unwisely. We look upon it as being really an investment in national well-being.

I realize in what I have just said I am making a broad claim. Engineers are practical men and some of you may be inclined to ask upon what I base my statement. The question is a fair one, and it brings us squarely up to an inquiry as to the results of modern methods of labor management—the results of this human engineering to which we have been giving consideration.

Should we be content to accept the often expressed opinion that the benefits are intangible and simply rely upon our faith to justify our efforts? Will the average citizen merely applaud this new order as a desirable and worthy ambition for better conditions on the part of the definitely affiliated factors in industry, or will he, whatever may be his calling, see beyond and realize that he is personally and profoundly affected?

Surely the engineer with his trained powers of analysis will be among the first to see the effect that these better relationships have had in advancing his own science, for he no longer finds an unenlightened resistance to the fruits of his genius. Indeed he has come to be regarded as an indispensable ally of employees as well as employers under this new order. And the benefits to employees in an improved economic status and to employers in increased good-will and productivity and steady operations are so readily recognized as to assure no backward step by either party.

EFFECTS UPON THE STABILITY OF BUSINESS

But I must go beyond merely the benefits to employers and employees, important as these benefits are, if I am to justify my statement that the money spent upon human engineering is an investment in national well-being. Let us turn then briefly to some of the advantages that have accrued to the nation and to society at large. To start with one of the most obvious, I believe that the present stability of business is due largely to the better relations that have been brought about between employers and employees. It was not so many years ago that buyers of basic products were under a constant fear that their supplies of essential materials would be interrupted by strikes, lockouts, or other overt expressions of industrial ill-will. They could not be sure of uninterrupted production. Therefore it was quite natural that they bought beyond their needs and laid up surplus supplies which, in periods of business recession, were dumped on the markets and added to the demoralization and stagnation which formerly characterized several downturns in the business cycle.

Today this situation has changed. It is only in a few industries, having special problems of their own, that there is at any time any serious danger of suspension. Buyers realize that they are no longer the victims of conflict and misunderstanding between management and labor in the producing industries. The confidence which they have therefore come to have in the ability of industry to supply continuously and uninterruptedly their requirements has revolutionized purchasing methods. Within the last few years we have seen the purchasing public abandon its long-established practice of rushing in to place orders upon a basis that required full-capacity operation for a time and then witholding its patronage during a period of lessened production, unemployment, and economic distress.

This new method of buying has gone far to level the peaks and valleys which formerly characterized the business cycle. It would be too optimistic to hazard the prophecy that these peaks and valleys have been entirely eliminated. Even the most conservative of us, however, has evidence that their extent and severity have been greatly reduced. For this important advantage to business and to the public I give much credit to the better relationships that have been built up between management and employees.

SUSTAINED EMPLOYMENT AND PURCHASING POWER

With this greater stability of business has come more regularity of employment. A few minutes ago I spoke of steady employment as one of the reasonable desires of the laboring man. Now, however, we should consider it from the standpoint of business as a whole and of the nation. Until recent years a large amount of unemployment was considered to be natural and inevitable, under certain circumstances. It might be caused by the stagnation resulting from the downturn of the business curve, or it might be voluntary idleness due to strikes and misunderstanding within industry.

Gradually it was realized that under the interdependent linking of one industry with another, enforced unemployment in one line of business might be the result of voluntary idleness in a related enterprise.

However diverse may have been the causes of unemployment, there was no doubt as to its harmful results not only upon the workman and his family but upon business and society. Injury to business and society became constantly greater in the measure that industry came to depend upon the purchasing power of the wage earner for a large portion of its market. It is surely apparent to us today that no section of our population can remain idle over a protracted period—whether involuntarily as a result of business decline or other circumstance, or voluntarily as a result of industrial misunderstanding—without this situation affecting the whole economic structure of our nation, for continuous employment and adequate buying power of the workers and a fair and steady return to investors are the foundation of our national well-being.

Human engineering, therefore, by improving the relationships between employers and employees, has lessened industrial conflict and misunderstanding, benefited workers and owners of industry, stabilized business through improving service to the purchasing public, and fostered the continuous employment at high wages upon which is built our present economic prosperity.

Opportunities for Further Service

Successful industrial management in the future is going to depend more and more upon management of men rather than upon the organization of machines and other problems which are ordinarily considered in the sphere of practical engineering. For the most part and generally speaking, the engineering profession may be said to have solved or laid the groundwork of solution for the essential problems of the engineer in his technical field. Experience shows, however, that industry's most important task in this day of large-scale production is management of men on a human basis. Not only is this essential as affecting production, but it is becoming increasingly more important toward the maintenance and development of industry's own markets, for under present-day economic conditions in America, workers are more than producers, they constitute the very backbone of large-scale consumption.

Let us hope that the new viewpoints from which industry is being regarded will hasten the day when we shall cease to talk about a separation between labor and capital and begin to think of management in an all-inclusive sense—a new concept of management to include employees and employers striving hand in hand to bring success to the undertakings in which they are engaged.

The opportunities for further service in industrial statesmanship and engineering are indeed immeasurable. We have not attained perfection but we have made real progress and reaped substantial rewards. This knowledge should hearten us to strengthen, perpetuate, and extend the principles of this new order of human relations, so gloriously started, that we may have a nation of contented, self-respecting workers and citizens, and a sound, prosperous, progressive industry in the interests of society at large.

In my belief that we shall continue to meet this challenge lies my abiding faith in the future of American industry.

Engineering Research and the Engineering Foundation

THE Engineering Foundation aims to undertake the class of researches that individuals, industrial organizations, colleges, and governmental bureaus are not likely to choose. Certain much-needed fundamental investigations can best be initiated or organized by such an institution as the Foundation. Great care is taken not to infringe on ground that can best be explored by spontaneous, individualistic effort.

An excellent example of the kind of large-scale research properly suited to the Foundation is what has come to be known as the Arch Dam Investigation. This was taken up in response to requests from engineers in the Far West. Among the agencies that cooperated in attacking this problem were the states of California and Oregon, the United States Bureau of Reclamation, the Bureau of Standards, the City of San Francisco, the County of Los Angeles, many power companies, four engineering colleges, engineers both in this and foreign countries, several bankers, and many manufacturers of equipment and materials.

In addition to the observations made on a number of dams throughout the West, a strong need was felt for a large experimental dam. After special efforts this dam was finally built on Stevenson Creek near Fresno, California, and equipped with instruments of exceptional precision for measuring strains, deflections, and temperatures. As the dam is 60 ft. high and 140 ft. long at the top, it permits practical experiments on a grand scale. Numerous problems in experimental technique have been solved by it in addition to those inherent in the design and construction of arch dams.

In order to test the breaking resistance of the dam, built of unreinforced concrete, based on a granite bottom and sides, many engineers have suggested that the height of the dam be raised from 60 ft. to 100 ft. or until it breaks under pressure. To do this would cost $50,000 additional. If special contributions be made or if the endowment of the Foundation soon increases measurably toward its goal of $5,000,000, such an expenditure may be possible.

Ingenious tests are being made also on a celluloid model of the Stevenson Creek Dam one-fortieth the size of the concrete dam. The results of these tests at Princeton University confirm remarkably the measurements on the large dam. Tests of larger models of this dam and of several other forms of arch dams are being undertaken in the laboratory of the University of Colorado at Boulder, under the patronage of the U. S. Bureau of Reclamation, which has its principal engineering office at Denver.

No arch dam—at least none built under engineering supervision—has been known to fail. Some have been built very thick and others surprisingly thin. Heretofore nothing has been definitely known about their factor of safety. When the information being gotten by this investigation is put into the hands of engineers, arch dams may be designed more intelligently and probably with more economical use of materials than in some of the dams which have been constructed.

This Arch Dam Investigation was reported in several progress bulletins as experiments were made, but a book of substantial size will be published soon in order to summarize in comprehensive form the valuable results of the work already done. This entire investigation is so aptly illustrative of the kind of research which the Foundation is best fitted to undertake that it is richly suggestive of numerous researches in other departments of engineering which may be taken up in the future as the income from the endowment funds permits. The entire engineering profession is bound to benefit as these large-scale researches on fundamental problems are carried out. Engineering needs just such stimuli to unify and arouse its cooperative spirit and to strengthen its bonds with the industries, the universities, the technical bureaus of the Government, and the endowed laboratories.

P. B. M.

Progress and Prospects in Mechanical Engineering

FOREWORD

A Review of Recent Accomplishment in Its Various Branches, Prepared by the Professional Divisions of The American Society of Mechanical Engineers

THIS is the third year in which the Professional Divisions of The American Society of Mechanical Engineers have presented reports of the progress made in their respective fields during the preceding twelve months. An analysis of recent progress as a basis for future planning is an essential for constant improvement, and the Professional Divisions are performing a valuable service in preparing and publishing these progress reports.

Advances in engineering are rapid, amazingly so. The Executive Committees of these Divisions have faithfully endeavored to present in these reports information as to present conditions and needs, and stimulus to renewed efforts in the coming year. The thanks and appreciation not only of our own Society but also of the whole engineering profession are due to those members of our Professional Divisions whose reports have come to form an important part of each year's technical literature.

CHARLES M. SCHWAB,
President of the Society.

Progress in Management Engineering

Contributed by the Management Division

Executive Committee: C. W. Lytle, *Chairman*, Geo. E. Hagemann, *Secretary*, Park T. Sowden, W. L. Conrad, Robert E. Newcomb, and W. R. Clark

AS THE United States achieved the greatest yearly production of goods in 1926 and also the highest productivity per wage earner, that year has been called by some a "boom" year. On the other hand, there were none of the unfavorable symptoms such as inflated prices, so that it should more properly be considered a year of steadily increasing prosperity. This increase of prosperity began in the middle of 1924 and might have met a considerable decrease in 1927, judging from the usual length of business cycles. While 1927 has had some such indications, they have occurred temporarily and in spots, so that the year as a whole has been prosperous. In fact, commodity prices have fallen gradually, and there has been little strain on the money market. Instalment selling, while now very general, seems not to have increased excessively, and there are many who contend that as long as there is little unemployment it is a wholesome condition. Perhaps the real basis of this unusually long prosperity is the fact that wages have been very much higher relatively than prices, thus enabling wage earners to consume increasing quantities of goods. This in turn indicates that productivity has also continued to increase. Referring again to 1926, the bank savings of the United States increased a billion and a half dollars during that year, and the number of depositors increased nearly three million, so that a new high per capita saving rate of $211 was established for the country.

The Savings Bank Division of the American Bankers Association reports that more than half a million of the additional savers were depositors in school savings accounts. On the other hand, it is claimed in reliable quarters that this saving is no more than the natural compound-interest growth of earlier savings. Referring to our present $770 income per capita, and over $3000 wealth per capita, Dexter Kimball says,[1] "For the first time since the world began we are in touch with the abolition of poverty, through the tremendous output of our products." Regardless of what other factors may have contributed to the stabilization of this prosperity,[2] a large amount of credit was unquestionably due to the rank and file of American management, for competition has been increasingly keen and the margin of profit consequently declining. What is being called "the new competition" includes inter-industrial competition and inter-distributing competition as well as the old inter-commodity and international competition, for today we have silk competing with rayon, leather with artificial leather, copper with aluminum, etc., and furthermore manufacturers are taking over distributing functions, thereby competing with jobbers, and some retail stores are doing manufacturing.

THE EUROPEAN SITUATION

Our Government reports that the exports of the United States to other countries for the year ending June 30 were $4,986,000,000 against $4,283,000,000 for 1926. Imports totaled $4,253,000,000, leaving a favorable trade balance of $733,000,000. Exports of foodstuffs amount to $381,000,000 against $250,000,000 for 1926. Our store of gold increased $148,000,000. Wheat exports were two and one-half times greater than the year before. Conditions in Europe have improved moderately, and their leaders are doing their best to gain the world markets. Foreign competition is therefore likely to affect us directly or indirectly

[1] "The Trend of Scientific Management," *Bulletin S.I.E.*, July, 1927.

[2] See "Stabilizing Prosperity," by Virgil Jordan, *Yale Review*, October, 1927.

to an ever-increasing degree. Mass production is being adopted as far as conditions will allow, and in both England and Germany there is a vast movement of regrouping and reorganizing. "Scientific Management in Great Britain,"[3] by L. Urwick, organizing secretary of Rowntree & Co. Ltd., describes the three periods in the growth of scientific management in Great Britain—the post-war period, followed by loss of interest in 1921 and a renewal of interest during the past year, the chief feature of which has been the formation of non-competitive groups interested in management research.

According to Edward A. Filene,[4] "Both the group-buying movement and mass production and distribution by large manufacturers have already advanced in Europe to a greater extent than many people realize. The chains of retail stores are progressing successfully in Germany and in England. As examples of successful modern mass manufacturing, there are the Morris car in England, the Citroën car in France, and the Batá shoe in Czechoslovakia, all of which are producing under mass organization and in mass quantities; but the trouble with Europe in large measure is that since the war it does not know how to buy its food or raw materials." Condemning the resort to tariff as a means of solving market problems, he concludes that "scientific mass production requires less and less tariff protection. The Chevrolet automobile or the Ford automobile requires no protection. Even with free trade it is inconceivable that any foreign automobiles could compete with these two in the United States markets. More than that, they could be produced very much more cheaply if the additional living cost that results from the tariff were removed, and therefore they could be exported and sold in still larger quantities than today." It is said that the name of Henry Ford is known in the remotest parts of Russia on account of the advent of the Fordson tractor.

The term "rationalization" as used in Germany is defined as: (*a*) increasing the profitableness of the industries by cutting down production cost of manufactured products to a minimum; (*b*) lowering sales prices so as to adapt them to the purchasing power of the consumers, and (*c*) making it easier for German products to compete in the world markets. They are also attempting some division of manufacturing or specialization on the part of individual plants and are establishing common sales bureaus to keep down overhead. In many ways they have gone beyond the United States in the matter of standardization.[5] On the other hand, with much less uniformity in the demands of European consumers, and with an oversupply of labor, the peculiar economic conditions of the United States are not likely to be attained.

Dr. Francesco Mauro, a leading industrialist of Italy, spent some time visiting American plants during the past year, and in summing up his impressions here, mentioned particularly the following items:

(*a*) High standard of living
(*b*) Freedom from radicalism
(*c*) Spirit of cooperation
(*d*) Amount of research.

He also paid high tribute to the influence of the late Frederick W. Taylor and Herbert Hoover. It is interesting to note the relative purchasing power of wages as reported by the National Industrial Conference Board. Taking the United States as 100 per cent, the purchasing power in Germany is 33 per cent, in Italy, 29 per cent, and in Great Britain, 57 per cent, and the average of 12 European countries is 41 per cent.

American industrialists and engineers have been welcomed as never before in Europe. As an expression of gratitude for courtesies shown the industrialists of Czechoslovakia, that government has awarded the Cross of Knight of the Order of the White Lion to five American engineers. Poland has also given the Commander's Cross of the Order of Poland to an American engineer who has served as an advisor for the past two years. In Geneva, Switzerland, there has been established an International Management Institute. Henry S. Dennison, the representative of the American Management Societies in Europe, reports that "there have been no revolutionary changes, but a considerably intensified carrying on of betterments not only in machines, but in the layout and arrangement of departments. Improvements in internal transportation facilities of every sort have been considerable during the past eighteen months." Edward Eyre Hunt, of our Department of Commerce, attended by invitation the World Economic Conference in Geneva last May and reports that "the emphasis on scientific management was very striking."[6] Forty-one countries were represented at the Fourth Congress of the International Chamber of Commerce in Stockholm last June, the U. S. having 162 accredited delegates headed by Owen D. Young. The Congress endorsed the conclusions[7] on rationalization and international industrial pools reached at Geneva by the Economic Conference. The main interest of the Congress centered on the subject of trade barriers. The retiring president, Sir Alan Anderson, called attention to the fact that there are 5,000,000 people out of work in Europe, as well as 20,000,000 others underemployed.

The third International Congress of Scientific Management was held in Rome during September and was attended by a number of American leaders. Their papers dealt with phases of "scientific organization of labor for industry, agriculture, public service, and domestic economy." In all, 176 memoranda were examined and resolutions were passed. Signor Mussolini made the closing address and asked the delegates to report that Italy was well ordered and was working out her own economic resurrection, for the progress of humanity and for peace between nations.

Economics of Industry

It is significant that three engineers were invited this year to participate in a Conference of Economists here in the United States. Certainly the American industrialist has contributed much to the newer science of economics in the last few years. One of these new economic questions is that of thrift versus buying. Under present conditions business men are encouraging the public to buy as never before. Since current savings must be taken from current income, the value of the consumer's goods which can be currently purchased will, of course, be less by the amount of the current savings. One school of thought has therefore gone so far as seemingly to deprecate thrift. This is answered, however, by pointing out that savings may be invested in two different ways: first, in circulating capital—goods which are to go into finished goods—and second, in permanent capital to be used as a factor of production. If savings are invested in the former way, the permanent productive factors of the country are not increased. Such a use of savings does cause an oversupply of goods on the market. However, most savings get into permanent-capital goods which are not sold but used for further production and therefore constitute an ultimate demand for existing goods and are just as much a final market disposal of the existing or future market supply of goods as is the purchase of an equal amount of consumer's goods. This does not cause a future oversupply of goods. The increase in production resulting from extended permanent investment, if a stable price

[3] See *The Management Review*, October, 1927.
[4] New York *Times*, April 3, 1927.
[5] See article by E. J. Mehren in *Engineering News-Record*, August 5, 1927.
[6] See Conference Resolutions in July, 1927, Bulletin of the Taylor Society.
[7] *Engineering News-Record*, June 9, 1927, p. 951.

level is maintained, will furnish a sufficient increase in the national money income to enable investors to purchase the additional amount of goods. The equilibrium between supply and demand can therefore be maintained under conditions of an increasing production if all savings are invested in permanent-capital goods.[8]

Since primary forces are increasing the purchasing power of the masses, the maintenance of this fundamental situation is more important than to overpersuade in the matter of buying. If unemployment can be kept down and wages kept up, there will be a constancy of ever-increasing purchase power. Another writer points out[9] that business is trying so hard to get business that it is saddling itself with all sorts of expenses in trying to make people buy more goods, with the result that gross business has increased but net profit decreased. Here we have the problem of keeping down overhead. There is little question but that much can be saved in this field in the future, although an encouraging number of corporations have already brought their overhead to lower proportions. Consolidation of allied lines in order to use common resources is one of the ways of accomplishing this, but this has not always proved a sure means and overhead can be reduced in many ways without it.[10]

Ernest F. DuBrul, secretary of the National Machine Tool Builders Association, reports as the most outstanding development in that field the application of statistical methods to management. He says they are translating corporate accounts into dollars of equivalent purchasing power for different years, thereby giving executives real facts instead of the accounting delusions they have sometimes had. In this connection it is also noteworthy that statisticians are no longer content to plot nominal wages but are using curves made up to real wages, that is, the purchasing value of the wage.

Such economic problems as the best size of production lots are being studied everywhere. As many variables are involved, no practical formula has yet been developed.[11] The problem of selecting the best combination of equipment is also being studied and a formula developed some time ago has been simplified so as to permit wider use.[12]

A new danger of obsolescence has come through the continual discovery of new processes. The German process of making wood alcohol threatens present methods. Before the new process of making sugar from corn is in wide use it is announced that better sugar can be made from artichokes. The employer must be more alert than ever to avoid an enormous loss in equipment.

Hand-to-mouth buying or the use of small orders has brought about uncertainty and hardship on parts manufacturers, but it has in the main freed capital and prevented overstocking.[13] The Packard Motor Company has reduced inventories in the ratio of 1 to 12 as compared with three years ago. The Hudson Motor Car Company is reported to turn over its material inventory every 14 days, and the Loose-Wiles Company, which handles perishable goods, every 24 hours. As a result of this, the problem of least-cost purchasing quantities is being studied.[14]

BUSINESS CYCLES

All industrialists seem to have learned the importance of leveling off the peaks and valleys of business. Forecasting conditions and coordinating sales quotas with production schedules is making progress.[15] The Policy Holders Service Bureau of the Metropolitan Life Insurance Company receives reports from 250 industrial organizations each month for analyzing and charting.

PLANTS

At least forty cities are advertising industrial sites. Some of these cities are selective in their approach, some are not. The employer must consider many things before he can attempt to find the one best combination of advantages. For brief statements of these principles see T. S. Rogers' two recent papers "Should You Lease, Buy, or Build a Plant?" *Manufacturing Industries*, September, 1927; and "Factors to Be Considered in Plant Location," MECHANICAL ENGINEERING, November, 1927. A particularly fine example of locating a new plant was given by O. C. Spurling in the June, 1927, issue of the last-named journal.

The past year has seen examples of illumination using as high as 20 to 30 foot-candles as compared with 10 to 12 foot-candles which was formerly considered a maximum.

EQUIPMENT

Not only has there been a great replacement of machinery due to improvements in design, but employers have been forced to seek every type of labor-saving device in order to offset the former supply of labor from immigration. Jigs and fixtures are being used in industries that never considered them necessary. Almost every skilled and semi-skilled worker today is supplied with some kind of special machine, tool, or fixture. Material-handling equipment, rapid-drying equipment, etc. are being installed in many processes where they have never been used before.

LABOR

The record of the year ended June 30, 1927, as regards the admission of aliens into this country shows an increase over the preceding year of somewhat more than 40,000. Yet the total for this year (538,000) is small as compared with the figures for 1913, so that the figures for 1927 are smaller than those for 1920, 1921, 1923, and 1924, but larger than those for 1922, 1925, and 1926.

Last spring a conference was called by the Philadelphia Labor Union and the Philadelphia Labor Institute, also with the cooperation of Central Labor College, of Philadelphia. Morris Llewellyn Cooke presided and later expressed the opinion that the growing interest of labor in the elimination of waste was one of the most encouraging developments. If carried into effect it may bring about an altogether new era. William Green, president of the A.F. of L., pledged the cooperation of union labor in every attempt to reduce waste, but declared that the resulting benefits should show proportionately in higher wages as well as in increased profits. G. L. Gardner, author of the new book on Foremanship,[16] also reports that foremen's organizations are studying waste-elimination methods more than ever before.

With the waning of prosperity conditions, manufacturers will face the difficult problem of stabilizing employment. Perhaps there is no more important problem than this. Prof. H. Feldman, of Dartmouth,[17] says, "Protect your sales program first. Analyze your markets, simplify lines, and reduce style

[8] See "Profits, Progress and Prosperity," by A. B. Adams.
[9] "Competition That Raises Prices," by Fayette R. Plumb.
[10] "How to Cut Overhead Expense," by J. H. Barber, in *Manufacturing Industries*, May, 1927.
[11] See paper by F. E. Raymond, A.S.M.E. Management Division, Management Division Quarterly, Jan., 1928.
[12] See paper by George Hagemann, A.S.M.E. Management Division Quarterly, Jan., 1928. Also two articles in MECHANICAL ENGINEERING, September, 1927: "The Economics of Machine-Tool Replacement," by M. S. Curtis, and "Shop-Equipment Policies in Representative Plants," by L. C. Morrow.
[13] See "Building Cars Without a Stockroom," *Iron Age*, Mar. 17, 1927.
[14] See article by R. C. Davis in *Manufacturing Industries*, May, 1927.
[15] "Business Annals," by Thorpe and Mitchell, and "Business Cycles," by W. C. Mitchell, National Bureau of Economic Research, Inc., 474 West 24th Street, New York City.
[16] A. W. Shaw Co.
[17] "Regularization of Employment."

hazard." This is important to labor as well as to capital. Reasonably steady, regular, and continuous employment creates a better state of mind, begets a feeling of confidence, and permits workers to make orderly planning for the future. L. F. Loree[18] describes a novel measure to meet this in what he calls an "elastic" work day. It consists in varying the length of the working day between eight and ten hours in accordance with the fluctuation and volume of business. He claims it could entirely obviate the necessity of layoff.

The increase in labor productivity has been most encouraging, although figures are not up to date. The Bureau of Labor Statistics, Department of Labor, has made a study of this from 1914 to 1925,[19] and reports the following percentage increases:

Automobiles	172	Leather tanning	26
Boots and shoes	6	Paper and pulp	34
Cane-sugar refining	28	Petroleum refining	83
Cement manufacture	61	Rubber tires	211
Flour milling	40	Slaughtering and meat packing	27
Iron and steel	59		

The Bureau of Labor Statistics is also conducting an investigation into the efficiency of labor in various European countries. The assistant commissioner of the bureau was in Europe last summer and made studies in Great Britain, Belgium, France, Germany, Czechoslovakia, Austria, Switzerland, and Italy.

Over 500 industrial disputes have been handled by the Conciliation Service of the Department of Labor during the fiscal year ended June 30. These disputes affected either directly or indirectly half a million workers, and it is stated by the Director of Conciliation that more than 85 per cent of the cases handled by his office have resulted in satisfactory settlements.

The Travelers Insurance Company estimates that 27,000 American workmen will receive around $50,000,000 this year in benefits from group insurance.

Standardization and Simplification

Standardization of design has made great headway. It has reduced the amount of work in the drafting room to a minimum and is doing much to keep down stock requirements. That standardization is opposed to specialization is called a fallacy[20] by W. S. Heyward, who claims it is often possible to specialize a standardized line and to make it distinctive.

Simplification, under the leadership of Herbert Hoover and the able assistance of R. M. Hudson of the Division of Simplified Practice, Department of Commerce, has spread far and wide. There are few industrial lines which are not now working in this direction. For example, the Norwich Pharmical Company has reduced the number of items produced from 4000 to 400. During the year it has been taken up by some foreign industrialists and is considered to be one of the great contributions of American Management.

Conservation of Material

The Department of Commerce last April reported a reduction in the use of raw rubber amounting to 22,000 tons over the preceding year, despite the fact that motor-car registration increased nearly 10 per cent. No doubt simplification has been accelerated by the tendency to buy for immediate needs only. An interesting method of controlling rejections, that is, defective production, is described by P. F. Cooper.[21]

Marketing

The trend is toward intensive rather than extensive marketing. With this in view some national advertising is being placed in local newspapers instead of in magazines and other expensive mediums. Part of the advertising budget is being taken for research to ascertain what the consumer really wants. Professor Freeland of M.I.T. says, "Market evaluation must be based on inclination to buy as well as on capacity to buy." The study of distribution waste has gone on with particular attention to such practices as overselling, cancellation and returns, delays on deliveries, unethical credit practices, and discrimination. The difficulty in this problem is that it lies in the twilight zone between the manufacturer, the wholesaler, and the retailer. Functionalization has therefore penetrated this field, and the term "merchandizing"[22] is being used for the function between sales and production. That is, pricing, balancing of inventories with production schedules, and analyzing of advertising mediums is being solved by unprejudiced staff men. This is sometimes carried on under a sales planning department. Some leaders are warning industry not to go much further in "morgaging future income." The importance of establishing prestige in business is being discussed.[23]

It has been claimed that buying materials on specification instead of by trade name will save the United States annually one billion dollars. The United States Bureau of Standards alone is said in this way to have saved 100 million a year on purchases. The new simplified invoice has been formally accepted by 12 associations and over 100 important business concerns, as well as by the Federal Specification Board. It is expected that this will come into general use in a short time. During the past five years the American Railway Association has reduced the entire carriers' payments on damages from 120 million dollars to 38 million.

Clerical Operations

Many are taking steps to reduce the cost of office work. Simplified practice, better arrangement of desks, and the segregation of typists have done much. Typists and other operators of mechanical devices when placed in a group subconsciously fall into the rhythm of the group, and a slow operator entering the group will pick up a certain amount of speed. In addition, it is important that each clerk be assigned a full day's work, which is of course the result of job standardization or time and motion study.

Safety

The survey of the Engineering Council has been published encompassing the experience records of about fourteen thousand companies and over one-fourth of the industrial work of the country. The figures show conclusively that a decreasing productivity is usually attended with a corresponding increase in the frequency and severity of accidents, and vice versa. The report includes numerous charts and shows trends in both accidents and production of 16 basic industries. "The rate of production per man-hour for the industrial groups studied," it says, "was 14.4 per cent higher in 1925 than in 1922. The rate of accident frequency per man-hour was 10.4 per cent lower in 1925 than in 1922. The rate of accident severity per man-hour was 2.5 per cent higher in 1925 than in 1922. Many industrial executives have not given to accident prevention that degree of attention and direction which its economic and humanitarian significance warrants. There is evidence to the effect that some industrial executives feel which because of compensation insurance carried, their responsibility has been met, hence they do not concern themselves with accident prevention. The initi-

[18] *Industrial Management*, March, 1927.
[19] See Handbook of Labor Statistics.
[20] "Sales Administration."
[21] *Manufacturing Industries*, May, 1927. See also three papers on "Control of Quality," A.S.M.E. Management Division Quarterly, Jan., 1928.
[22] E. A. Filene in "More Profits from Merchandising."
[23] "An Analysis of Prestige," by Ernest Urchs of The Steinway Piano Company, *The Music Trades*, June 25, 1927.

ation of accident prevention is as much a responsibility of the major executives as is the initiation of improvements in productivity."

The United States Steel Corporation has been a pioneer and leader in accident-prevention work. Not long ago it issued a report in which it was estimated that as a result of organized safety campaigns within the company over the period from 1912 to 1923, inclusive, more than 35,000 employees were saved from serious injury. The American Car and Foundry Company, another outstanding example in this field, spent approximately $1,000,000 in fourteen years for accident prevention, but estimates that it saved $2,700,000 in actual loss by this expenditure.

There is now going on an investigation of light, sight, and safety, from which much is expected.

Traffic Devices

The American Engineering Council has a committee at work on street signs, signals, and markings. Over sixty leading cities have submitted data, and it is hoped to include 250 cities before they finish.

Fatigue Elimination

Dr. A. T. Poffenberger, Department of Psychology, Columbia University, has carried on experiments in his laboratory which measure the amount of oxygen and the amount of carbon dioxide involved in certain work. He has found that the efficiency of the human body as a prime mover varies much as other prime movers. For instance, there is an optimum speed for every kind of work. By his methods he is able to determine the capacity for work and the energy cost of work increments. He points out that this type of measurement must precede the study of fatigue in its relation to ordinary output, but thinks it entirely feasible to approach that relationship later on. It is proposed to eventually make studies on many types of factory work under varying conditions of monotony, noise, light, etc. As similar studies are being made at the Kaiser Wilhelm Institute in Berlin, the problem of fatigue is at last being put upon a scientific basis.

Joseph A. Piacitelli describes[24] how the Barber Asphalt Company eliminated fatigue by rearrangement of machines and by better material handling. A 20 per cent reduc ion in the unit labor cost was the result. A similar reduction of 18.2 per cent in unit labor cost is described by W. C. Hasselhorn.[25]

A. B. Segur of Chicago says: "Nerve fatigue is apparently more important in industrial operations than muscle fatigue. On fast operations very few individuals are able to maintain the same operation for more than 15 seconds without making a mismovement. In industry, fatigue forces the operator to use a longer method of performing the operation, and therefore slows down the operation."

Dr. F. Hahn and S. F. Csohar, of F. B. Gilbreth, Inc., have been studying the subject. They have compared the motion of human arms with the motion of the pendulum, and from the pendulum law point out that either to accelerate or retard the natural motion requires an extra effort, causing fatigue. They say there is superfluous fatigue if a wrong path is used or if the distribution of time along the path does not correspond with a simple harmonic motion. Undoubtedly the Gilbreth micromotion method which uses a motion-picture film is well adapted to this study, and may be expected to develop definite laws. Dr. D. A. Laird is conducting research on the noises of cities. So far it is a matter of measurement rather than of prevention, but there seem to be great possibilities in what may follow. Dr. Laird declares that noise exceeding 35 units in his scale of measurement actually increases the blood pressure of human beings exposed to it. Note also the work of Prof. H. J. Spooner of London.[26]

Vacations with pay[27] are becoming the rule and are doing much to stimulate the loyalty of employees as well as allowing them a change without financial worry.

Incentives

The National Metal Trades Association is making an extensive study of wage incentives among their companies. Interest in incentives seems to be gaining, and L. P. Alford, editor of *Manufacturing Industries*, has observed that industries having the highest productivity also have the highest percentage of workers on some incentive plan.

Sales executives are trying incentives of all kinds, and find that by a few changes in terms the experience developed in the factory is applicable to their field. The cutting of piece rates or commission rates has become uncommon, and the response to such incentives is therefore more wholehearted than ever before.

Research

There has never been so much importance put upon research as at present. The Western Electric Company maintains a staff of 2000 for this purpose, with an annual expenditure of more than 8 million dollars. General Electric and General Motors each spend over a million annually.[28] Concerns which cannot afford these large expenditures are either working through their trade organizations or through the facilities of universities. The American Gas Association has a comprehensive program. Systematic use of research during the last five years is believed by the Copper and Brass Research Association to have been largely responsible for doubling the consumption of copper during that period. In some cases the trade organizations have raised endowments and have used them to build and maintain laboratories on university grounds. For instance, the Tanners' Council of America and the Lithographic Technical Foundation have done this at the University of Cincinnati. The precedent of the University of Toronto retaining the patent rights from basic discoveries, is being followed in several cases. There has recently been formed a Druggists' Research Bureau, to act as a national clearing house for obtaining facts necessary to the welfare and success of the drug industry. All this is partially a result of the tendency to abandon the rigid secrecy which companies have so frequently thought necessary.

One of the most important and significant developments in this direction has been the formation of a research organization by the U. S. Steel Corporation. Here the subsidiary companies carried on a good deal of valuable though uncoordinated research and invention work for years, but the parent company kept aloof. The new body has been given a particularly high standing in the Corporation by a provision under which it is made to report to the Finance Committee, the highest governing board in the Corporation, and by having such men as Professor Millikan and Professor Johnston to direct its destinies.

Miscellaneous Application of Management Principles

There has been some reorganization of governmental departments. For instance, the U. S. Patent Office has been studied by two engineers and a sub-committee. The report contains 108 recommendations which would considerably simplify practice.

[24] *Manufacturing Industries*, July, 1927.
[25] Ibid., August, 1927.
[26] *S.I.E. Bulletin*, Sept., 1927.
[27] "Vacations for Industrial Workers," published by the Industrial Relations Counsellors, Inc.
[28] See National Research Council Report, *Iron Age*, Sept. 1, 1927, p. 567.

Department stores are beginning to hire management engineers and are doing a great deal to eliminate waste. In one New York store the cash clerks have been studied by micromotion and their work standardized in the "one best way." The psychiatrist is being consulted in the matter of selecting clerks, and it is said by executives that this has proved profitable. Chain stores are succeeding by leaps and bounds, and they are doing this by the same principles used in mass production.

Agriculture is turning to research in the matter of mechanical equipment. A survey recently made includes over 400 suggestions for research. The Department of Agriculture expects to follow these up. Under the guidance of Mrs. L. M. Gilbreth, a series of lectures have been delivered at Columbia University, in which engineers have described the possible applications of management methods to the home.[29] Interest was keen. Interest was also evinced in this subject in the conferences held in Europe in the past summer. Similar reports come from prisons, hospitals, and schools at which various engineering methods are beginning to find adaptation.

Management Societies

The New England Council, composed of eight men appointed by the governor of each state, 48 men in all, assembled about 2000 men at Springfield, Mass., in November to discuss management in manufacturing.

The American Management Association has established an Institute of Management, membership in which is elective and based on achievement in management research. The very large number of company and research sustaining members which this association has secured indicates a greater interest on the part of high executives than has ever been shown before. The Management Division, A.S.M.E., has prepared a bibliography which is more comprehensive than any heretofore published.

L. P. Alford's paper on the "Laws of Management," mentioned last year, was the first to receive the Melville Award.[30]

Costs

Competition is forcing cost finding into all phases of manufacturing. For instance, the Utica Knitting Mills studied their factory heating and found that by revamping their old system they could save $17,000 annually. Similarly there is a renewed effort to reduce the cost of power. Hubert Collins reports four instances in which savings have been accomplished amounting to 23, 19, 13.5, and 11.8 per cent over former costs.[31]

The spread of standard cost methods has continued and is being fostered by trade associations. Manufacturers are studying labor costs as compared with carrying charges of mill equipment. The cost of obsolescence is becoming of particular interest. Budget control is almost universally in use.

Education

Courses in industrial engineering have not increased in number as rapidly as have courses in business administration. There is, however, an increasing tendency to offer options in management to engineering students. Rutgers University, New Brunswick, N. J., has recently offered a new four-year course in industrial engineering. It is an option in the Department of Mechanical Engineering and leads to the degree of B.Sc. in M.E.

The American Council on Education is using its influence to have schools make more accurate records of conditions in all types of occupations in order to aid employers in selecting material for employment.

Trade associations are raising endowment funds for private institutions conducting courses in their particular fields. As an instance of this, the United Typothetae of America has established an endowment of $225,000 at Carnegie Institute. The Association of Cooperative Colleges held its second annual convention in Philadelphia last June and was more largely attended by employers than by educators. This is considered a very encouraging aspect. The convention proceedings may be purchased from the Secretary.[32]

Industrial Museums

New York City has assigned to the Museums of the Peaceful Arts seven city blocks on the site of the Jerome Reservoir. This movement was started nearly 20 years ago by some of New York's public-spirited citizens: Judge Gary, Jacob Schiff, George F. Kunz, and Henry R. Towne. Calvin W. Rice was elected secretary, and Dr. Kunz, president.

At the time of Mr. Towne's death he left his residuary estate, amounting to approximately two and one-half million dollars, for this project, provided it should be successfully promoted. It would seem now with the recognition by the city of New York that the Towne bequest would become available.

Other movements, such as the National Museum of Industry, which was planned to be affiliated with the Smithsonian Institution in Washington, the Museum in Chicago, the original bequest for which, three million dollars, was given by Julius Rosenwald, supplemented by five million dollars by the city of Chicago, and the old building of fine arts occupied during the World's Fair, have been started since the original movement for the Museum of Peaceful Arts. But it is stated that they can all be made a national movement for the benefit of the whole nation as a part of the education and inspiration of all those engaged in industry.

Similar museums are proposed in Pittsburgh and in Philadelphia. The national engineering societies have indorsed both the movement for the Museum of Peaceful Arts and the National Museum of Industry, and all engineers generally should become identified with this movement as a direct contribution of the engineering profession to industry.

The Museums of the Peaceful Arts now occupy temporary headquarters at the *Scientific American* Building, 24 West 40th Street, New York, where a start has been made in organizing a great industrial technical museum for the city of New York.

Management Week

The subject this year was Management's Part in Maintaining Prosperity. Cecil Ashdown, vice-president of Remington-Rand Company, was chairman of the National Committee, and R. M. Hudson, of the Division of Simplified Practice, was secretary. The movement has become one of national interest and has secured the support of many non-engineering organizations.

Waste Elimination

While all of the foregoing indicates encouraging progress in the general elimination of waste, there is still a great deal which has not been done. The American Society for Thrift estimates our annual waste of coal at 750 million tons, of water at 50 million horsepower, of oil at one billion barrels, of lumber at 5 billion cubic feet. The Department of Commerce estimates that our annual waste in transportation equals one-half billion dollars, and says the shipper is largely responsible.

While materials handling has been studied more than ever, it is still thought that one billion dollars could be saved annually on payrolls by better use of present equipment and arrangement.

[29] "The Home Maker and Her Job," by L. M. Gilbreth, D. Appleton & Co., "Homemaking as a Center for Research," Bureau of Publications, Teachers College, Columbia University.

[30] See MECHANICAL ENGINEERING, April, 1927.

[31] *Manufacturing Industries*, August, 1927.

[32] C. W. Lytle, New York University, University Heights, New York City.

There were 135,000 commercial failures from 1920 to 1926-1927, inclusive, with total liabilities of $3,500,000,000. Seventy per cent of all the failures in 1924–25 and 25–26, occurred in the trading groups, and their share of the total liabilities increased from 37¼ per cent in 1924 to 49 per cent in 1926. Bradstreet's analysis of causes of failures during the years 1922 to 1926, inclusive, gives "incompetence" as the reason for 35 per cent of the cases, and "lack of capital" for 33 per cent more. The other 27 per cent are scattered among "inexperience," "extravagance," "speculation," "fraud," etc.

Finally, although most of the bankers and leading financial men are far from pessimistic, they are advising their correspondents and clients to get their affairs in better liquid condition for the spring of 1928. As far as the engineer is concerned, his influence has definitely increased and his doings are becoming desirable news for publication. The owner of business is now less apt to confuse the mechanisms of management with the spirit of management, and thus the reaction against so-called "efficiency" is vanishing.

CHAS. W. LYTLE, *Chairman.*

Progress in Materials Handling[1]

Contributed by the Materials-Handling Division

Executive Committee: R. H. McLain, *Chairman*, M. W. Potts, *Secretary*, J. A. Shepard, G. E. Hagemann, F. D. Campbell, and C. D. Bray

STURDY progress has been made during 1927 in the development of materials-handling equipment and in the application of that equipment to the needs of industrial plants, mines, construction, railroads, and marine carriers. While no outstanding advances are to be noted either in equipment design or use, there is no question but that the past year marks the active start of a transition period during which the business of materials handling will evolve from an empirical art into a scientific technique. Increasingly, profits, in materials handling must depend upon the precise fitting of equipment to the work to be done and to the coordination of the various handling units in a given installation in such manner that overall economies become maximum.

In the preparation of this report questionnaires have been circulated among several hundred concerns using materials-handling equipment, among practically all concerns whose business it is to design and to lay out plants, among representative builders of every recognized type of materials-handling equipment, among editors of representative industry publications, and among executive secretaries of industry associations. Equipment builders have been particularly helpful and have supplied your committee, not with propaganda, but with basic facts believed to be of value in recording progress of the year. Strangely, those concerns designing and specifying equipment for plants, both old and new, have failed to contribute anything whatever that is pertinent to this record. From each of the other groups questioned at least a few leaders have responded fully.

Approaching the subject first from the equipment point of view, we note that most developments have been in line with modern-equipment construction practice—whether for materials handling or for other purposes. Steel is coming into use in place of heavy castings, welding is supplanting riveting, simplification and exact machining for interchangeability of parts is becoming more common, improved bearing construction and better lubrication—these are basic trends.

With these developments in equipment, a better concept of the place of materials handling in production is reflected in—

1 Development of more effective organizations for materials handling, as at plants of the Otis Elevator Co., Westinghouse Electric & Manufacturing Co., Crompton & Knowles Loom Works, B. F. Goodrich Tire & Rubber Co., Hudson Motor Car Co., New York Central Railroad Shops—to mention but a few.

2 Building new plants around the transportation system rather than the transportation system around the plant—The Buick foundry, West Coast Porcelain plant, and A. O. Smith frame plant are cases in point.

As for particular developments in various types of materials-handling equipment, the following facts are significant.

CRANES

Evidence of special effort to meet special conditions and requirements with an assembly of standard units built by quantity-production methods is notable. In addition to the general equipment trends noted above, that hold for cranes, the use of I-beams in place of expensive riveted box girders, the speeding up of light cranes, the reduction in size of electrical equipment and power drives, greater compactness of design securing lightness with strength, increased ease of operation, lubrication by oil baths and reservoirs abolishing the old grease cup—all of these changes are taking place. Crane manufacturers feel that users of this equipment should not be concerned with trick bearings, special limit switches, motors, and control apparatus which are being urged upon them by independent manufacturers not directly concerned with the building of materials-handling equipment.

Within the last six months another development is reported that is believed to open a big field for the effective use of crane equipment in wire mills. This is in connection with the cleaning house and baker. One company has developed a special cleaning-house crane with electrical equipment so arranged that acid and fumes from the acid cannot with any great degree attack the electrical equipment. This consists of a single-leg gantry crane with the motor located near the floor, and in connection with this scheme it is necessary to arrange the tubs in which the cleaning is done in what are called "straight" floors instead of circular floors with the old type of circular crane that is in use in practically all wire mills today. The first application of this device will shortly be made at the Bourne-Fuller Steel Company in Cleveland.

HOIST AND TRAMRAIL EQUIPMENT

Fitting hoists and jib cranes to machine tools more extensively is considered significant. The installation of electrically controlled monorail switches at the Maytag Company's plant, representing a modification of an earlier installation at the

[1] When published later in quarterly form, this report will include a bibliography comprising some 400 items.

Saco Lowell Shops, is considered by a firm of consultants in Detroit to be worthy of mention. The installation of remote-control equipment of this kind speeds up a monorail just as the automatic street-car switch, which is controlled by the motorman, speeded up the street car a few years ago. The use of electric hoists in connection with skid equipment moved by 10-ton-capacity electric trucks has made possible revolutionary changes in the method of handling sheet steel in and out of freight cars.

Proportional pressure control for brakes on large hoists used on mining machinery is reported to have been perfected during the year.

New applications of tramrail equipment are reported—as in the warehouse that arranges the split-package stock in the same order in which orders from the stores are written up. This is usually arranged up and down both sides of several aisles equipped with the tramrail system and with a rack adapted to take an ordinary warehouse truck. This truck is installed upon the rack, and three racks are hooked permanently in a train. The men filling orders walk along the aisles and the carriers are propelled by electricity along the rail at either 25 ft. per min. or 300 ft. per minute. The speed is fixed by means of push-button control.

A recent tramrail installation made at the plant of the Manchester Terminal Warehouse Company, Manchester, Texas, involves the use of 150 electrically propelled carriers that are sending four bales of cotton along the rail like a cash carrier in a dry-goods store, eliminating the necessity of men traveling with each load. There are 17,000 ft. of rail involved on this system, and the rail is so arranged that there is no possibility of two carriers going in opposite directions colliding with each other, and it is also possible to get from any place in the receiving or shipping department and warehouse to any other place in the entire plant. This installation is causing considerable comment in the cotton warehouses of the South at the present time.

Elevators

Increasingly, elevator equipment going into both old and new plants is being fitted to the transportation needs. Elevators capable of carrying a train of one electric tractor and 4 trailers to any floor of an 8-story building is typical of developments of this kind that are taking place. Micro drive for self-leveling elevators, while not a new development within the year, probably has won wider acceptance recently than ever before.

Electric Industrial-Transportation Equipment

Storage-battery electric-truck manufacturers have widened equipment types available, and report an increasing sale of specially modified equipment engineered to meet precise service conditions. The use of live skids with lift trucks for handling freight in railroad l.c.l. service is reported to be on the increase. More high-capacity trucks are being built—from 5 to 10 tons—to meet the growing demand for the movement of heavier loads with fewer trips and hence with the expenditure of fewer man-hours. The Hudson Motor Car Co.'s materials-handling installation, around the use of 10-ton trucks, is pronounced by one disinterested authority to "excel what Ford has done." The perfection of the automatic coupler is another development of significance in connection with this type of equipment. This reduces personal injuries to workmen. In trailer design, aside from the new couplers, one definite development is the unit trailer employing a lifting device to raise reels of wire—holding them in the raised position during transport.

In the lift-truck field, a newcomer is noted in a unit to carry approximately 3000 lb., using a mechanical lifting mechanism actuated by the foot, while employing electric power in the usual manner of transport. This truck is designed to carry the 7-in. skid which has been developed for the older type of hand lift truck.

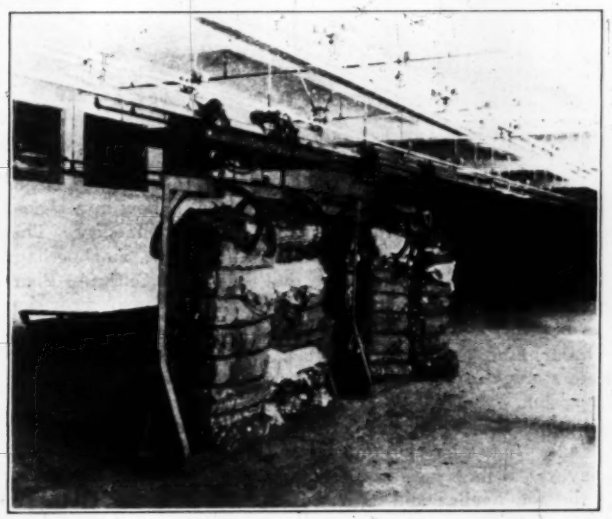
The most recent development by one company is an attachment to the crane truck. It consists of a heavy steel plate 30 in. wide, bent at an angle which is slightly acute and slidably mounted on a pair of steel channels which are attached at the upper end to the boom of the crane, and at the lower end to the coupler on the end of the truck. At the upper end of the steel plate and projecting from it is a curved plate-steel arm pivotably mounted. The hook of the crane cable is attached to the end of the arm nearest the steel plate which slides on the verticals. When the crane cable is wound up on its drum the strain raises the inner end of the arm and depresses the outer end so that it comes in contact with any article such as a roll of paper placed on the lower and horizontal portion of the bent plate, securely holding it in place while the plate slides up the vertical channels. By this simple device 1400-lb. rolls of newsprint paper are picked up where they have been landed on a pair of 2-in. × 6-in. planks placed just far enough apart to permit the horizontal portion of the bent plate to be inserted between them, and are carried to any point where the paper is to be stored. When lowered, the point of the bent plate touches the floor or a roll which has previously been placed. As soon as the tension on the crane cable is relieved a spring raises the arm, allowing this roll of paper to run down the bent plate and off into the position desired by the operator. By this means the truck operator, without assistance, can pick up, carry, and pile these awkward packages four high. When it is desired to use it as an ordinary elevating conveyor, the arm may be quickly removed and the crane cable attached directly to the end of the vertical portion of the bent plate. Means have been provided for adjusting the vertical members on which the bent plate slides so that various fixed angularities to the vertical may be obtained to suit varying commodities and conditions. In actual performance, ship's tackle raises two rolls at a draft. Two trucks equipped with cranes and paper-carrying attachments worked one hatch on a haul of about 350 ft. and less. The maximum performance was 104 rolls of paper per hour for the hatch, and nearly 100 rolls per hour average for the ship.

Hand Lift Trucks

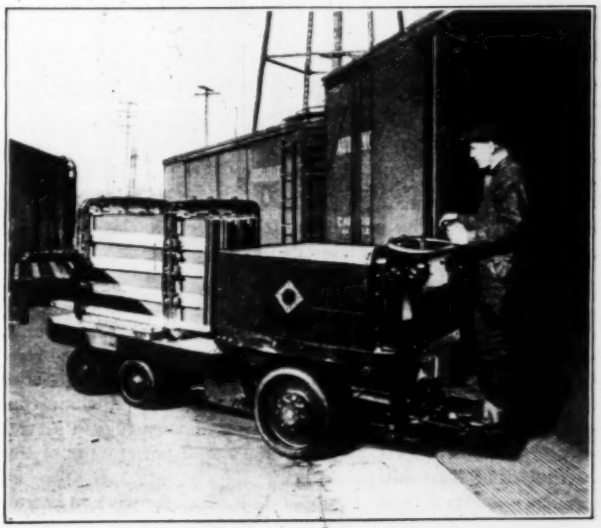
While there have been no radical changes in the design of portable elevators or lift trucks during the past year, the use of these forms of handling equipment has been extended to the solution of a wide range of handling problems. A very large percentage of the stackers now being furnished by the manufacturers are of special design, to meet special problems. Another distinct trend is toward the telescopic-frame type of portable elevator, which is suitable for use under balconies and low ceilings, and which may without any changes in the machine be extended in height so that it reaches to the ceiling of higher rooms of the plant. Another aid to the lift-truck method of handling has been the recent improvements which have been made in skid construction. Until comparatively recently the skids were made locally. Now, however, the lift-truck manufacturers have developed more durable and serviceable skids with steel frames. Because of the large number of skids made this phase of the industry now receives the attention which it deserves.

Skid Shipment of Materials

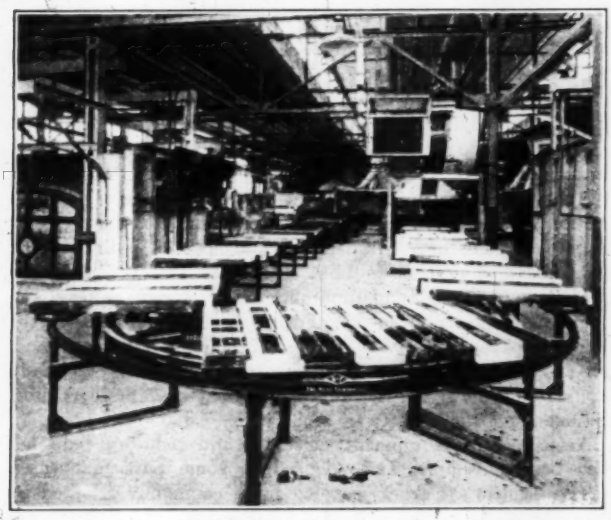
Skid shipment of materials on an increasing scale represents a trend in handling that cannot be ignored. Improved tying methods for securing skids loaded with various commodities promise still further development of this system in new fields.



Loading Point for Tramrail System in Cotton Warehouse

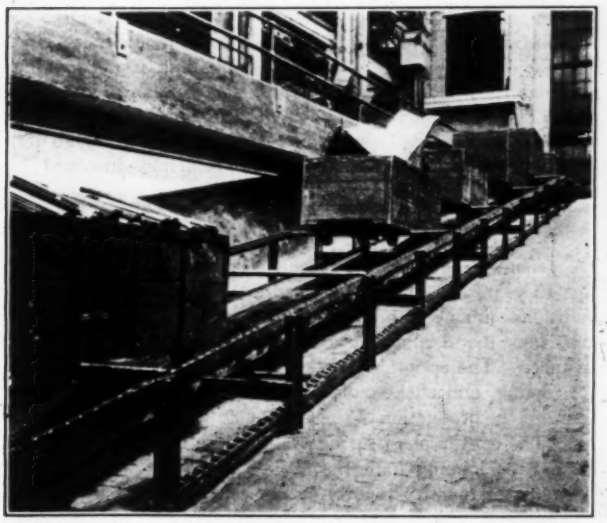


Electric Truck Handling Skid Shipment

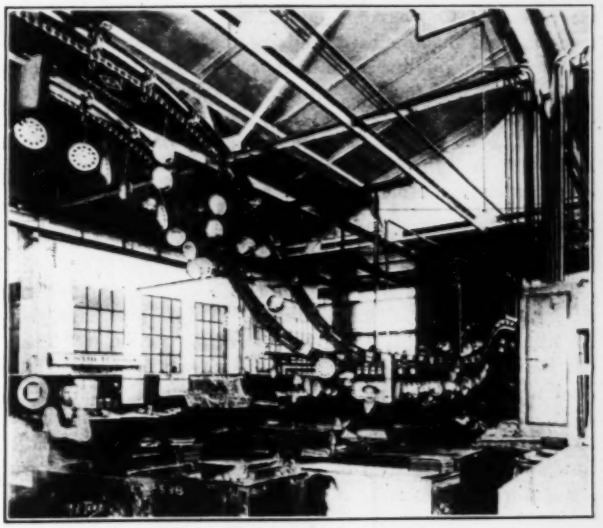


Carrousel Conveyor

Dust-Proof Gravity Roller Conveyor in Foundry



Chain Conveyor for Hand Trucks



Trolley Conveyor Using Link Chain

Originally put to work in the paper industry, at least one notable new effort that has been successful has been putting skids to work between plants supplying railroads with supplies and their central storehouses. In turn, when these supplies are sent to line stores, the skid load is transferred intact. Mention is made elsewhere of the use of 10-ton electric lift trucks at the plant of the Hudson Motor Car Co. There fullest possible advantage is being taken of the economies to be derived through wider use of skids for handling materials in transit.

GASOLINE TRUCK AND TRACTOR EQUIPMENT

In the field of gasoline equipment, a new gas-electric unit, designed for use in the battery compartment of a standard electric truck chassis, is to be noted. Improved characteristics for the unit, which is direct-connected instead of chain-connected, are claimed. For certain types of very rugged service as in forge shops, it is reported that the use of power units of this kind is being discontinued.

A new gasoline tractor of smaller dimensions for work in narrow aisles and for inside haulage, equipped with a so-called condensing silencer, has been introduced, which is said by its manufacturer to be capable of 24-hour service with remarkable economy.

CONVEYORS

Idlers for belt conveyors have been improved, mainly through the perfection of bearings. Improved casings for elevating conveyors are noted. Chains and other conveyor parts to resist acid and alkaline atmospheres are in course of development. (This incidentally holds for the materials used in the construction of most types of materials-handling equipment.)

Particularly important developments have taken place during the year in the underground conveying of coal. Mechanical loaders for working at the room face are making it possible to maintain a given production with a much smaller number of rooms.

Use of single conveyor lines for carrying products of varying size is noted. Increased employment of overhead chain-type conveyors also is noted.

PNEUMATIC EQUIPMENT

A type of pneumatic conveyor which has been built commercially somewhat less than a year has produced results which show important economies over other types of pneumatic or steam conveyors. As is the case with any new equipment, it was necessary to overcome difficulties, correct errors in construction, and make substitutions of materials and alterations for convenience of operation. A very recent test conducted in a plant having four 500-hp. boilers shows very satisfactory results.

The ashes at this plant are extremely variable in character due to the fact that wood refuse is burned under two of the boilers, while the other two are fired with a mixture of wood refuse and coal. In addition to the above, crating, boxes, etc. are broken up, and with the nails, form a rather heavy ash. Also there are a large number of sanding machines in the plant, and the fine wood refuse contains a considerable amount of sand which fuses with the ash in the furnace. This forms a hard, glass-like slag, which weighs about 135 to 140 lb. per cu. ft. Therefore the material to be handled ranges from light, fine, fluffy ashes to heavy slag weighing up to a maximum of 140 lb. per cu. ft. All of this material is handled through a duct having an internal diameter of 5.75 in. Tests conducted on this installation show an average capacity of about 13 to 15 tons per hour, with a steam consumption of about 240 lb. per ton of materials handled.

INDUSTRY DEVELOPMENTS

LAYOUT STUDIED IN PAPER INDUSTRY

The layout of the modern pulp and paper mill has been getting a great deal of study by the industry in an endeavor to reduce to a minimum the labor in handling raw products. The entire plant has been so designed that the materials flow in a logical manner from the raw product to the finished commodity. This has involved considerable handling equipment, and perhaps the best example of the modern mill is the new Gatineau Plant of the Canadian International Paper Company. Provision has been made at this plant for adequate storage of pulpwood, sulphur, lime, and other materials, and the conveying systems from storage to the mill are well arranged and allow for future expansion.

Pulpwood handling has been given much consideration during the last year and a half, and several new methods of mechanical conveyance have been adopted. One of the most interesting is the new loading and unloading equipment used by the Anticosti Corporation for handling 4-ft. pulpwood to and from vessels. This equipment consists of a pulpwood grab or "trapper," which is lowered into a restricted basin filled with 4-ft. pulpwood. The load is transferred to the hold of the vessel, where it is tiered up. The unloading procedure is carried on in the reverse manner, by means of a platform which will hold about one cord, and this is lifted from the hold of the ship and dumped into a conveyor. This equipment makes it possible to load and unload pulpwood many times faster than by the old methods, and the cost of handling is substantially reduced.

Recently equipment has been developed to handle long logs by the use of a sling arrangement. This eliminates the necessity of cutting them into 4-ft. lengths, and speeds up the loading and unloading operations both from cars and vessels.

The use of air to handle granular material such as clay, sulphur, and lime has been adopted by a number of mills in the pulp and paper industry. The cost of handling is reduced, and, what is more important, the dust in handling is practically eliminated, thus giving the workmen a great deal more comfort in unloading such materials from cars.

Air conveying equipment for chips and semi-dry pulp has also been developed and adopted in some particular cases.

The electric lift truck is being more commonly adopted by the pulp and paper industry for a number of commodities such as lap pulp, pulpwood, paper, and similar materials that are piled on platforms. This method eliminates considerable handling, and in the case of finished paper reduces the damage of spoilage due to poor handling methods. The overhead crane has enabled many mills to solve the handling problems when such materials as baled paper, rags, and similar products are used. This equipment is also used by a number of the mills to handle finished and semi-finished paper, and although it is not essentially new, the mechanical principles involved are being used to a better advantage than several years ago.

FOUNDRY PRACTICE DEVELOPING

A general trend toward mechanization, which started perhaps 15 years ago, has been accentuated by highly competitive conditions among foundries. Mechanical handling, covering sand, fuel, metal, and finished castings, has made tremendous advances. The adoption of continuous molding, melting, pouring, cooling, and shake-out has greatly decreased the cost and increased the production of the larger plants producing a standard line. The continuous pouring system does not apply, however, to small or jobbing foundries.

A radiator foundry reports 50 per cent saving in floor space, a reduction of 75 per cent in the number of flasks required,

and that the production per man has been increased from 5.75 molds of one class to 9.70 of the same type per hour, and from 18.25 to 30.55 molds per man-hour on a smaller hob.

Every new foundry built and every shop which has revised its equipment has gone the limit on conveying and handling equipment during the past 18 months.

Improvement in quality of product and increased pressure on merchandising methods probably will have the major attention of foundry executives in the next few years. Cutting corners on production costs, and improvements in manufacturing methods along present known lines, probably have reached the high point, although many establishments still could apply these factors to existing practice.

THE CONSTRUCTION FIELD

Most of the motor-truck manufacturers are building special equipment for road-building operations. These include special-sized bodies, bodies divided into batch compartments, and wide-tired wheels to decrease the unit weight on the road subgrade. In one case a truck has been developed which dumps to either side or to the rear.

Power-shovel design and construction have recently turned toward the smaller sizes of shovels, $^1/_2$ and $^3/_4$ yd. capacity, resulting in speed, operating mobility, and adaption to a large volume of work which has heretofore been uneconomical for large-shovel operation. On gasoline shovels, air-operated clutches are contributing to flexibility of operation. Somewhat along the same line air engines are being used direct-connected to the crowding and swinging motions of one shovel.

On all construction equipment steel castings have been replacing cast iron and riveted structural steel. In the past year extremely large unit steel castings have been used on some equipment. In one case a power shovel uses a single steel casting for the entire body frame and the bearing supports for all of the main bearings.

Roller and ball bearings are becoming standard equipment. At the 1927 road show of the American Road Builders Association, fully 50 per cent of the machines exhibited were equipped with such bearings. Of the other bearings used on construction machines, most of them are bronze-bushed, and practically all are of the split type to facilitate easy adjustment.

Much activity has been evident in lubrication development. Pressure systems of the Alemite and the Dot type are becoming commonplace. A more recent development is the use of totally enclosed gears running in oil.

A hoist manufacturer has developed a three-speed hoist using a motor-truck-type transmission. Portable conveyors, both of the belt and bucket type, and belt-conveyor installations for handling stone, cement, and other construction material, are continually being adapted to new construction uses.

THE RAILWAY FIELD

The applications of materials-handling machinery and devices in the railroad field are so diversified and extensive that it is held by one close to the situation almost impossible to give any summary as to the progress which has been made with any degree of accuracy. It is known that in each department there has been a steady increase in materials-handling devices and equipment in the interest of increased efficiency and greater economy of operation. As far as is known, there have been no startling improvements adopted on an extensive scale in any of the departments. The progress has been more in the extended and greater use of equipment and methods which were adopted by the more progressive roads in recent years.

In connection with materials handling in the railroad field, reference may be made to the fairly recent utterance of an authority close to present methods of freight handling. He pointed out that long-haul profits are being needlessly sacrificed in the terminal handling of freight, estimating that a saving of $25,000,000 is possible through the fully effective use of mechanical freight-handling facilities already at the disposal of railroads.

Skid shipment, already alluded to, represents an important development certain to be more widely practiced in the future.

Another change in railroad practice that already has come in some sections of the country, is store-door delivery. This will involve a tremendous expenditure in new short-haul materials transportation, and because of the experience of the American Express Co., which is the largest user of electric street trucks in the world, it is believed that this may become a recognized type of equipment in this branch of railway service.

MARINE HANDLING

The most significant development in marine terminals during the past year, at least on the Pacific Coast, has been the remarkable increase in the percentage of shipments handled to and from such terminals by trucks and the decreasing percentage handled by rail. As shown by a paper read before the Pacific Coast Association of Port Authorities by Harbor Engineer Nicholson of Los Angeles, the future piers of Los Angeles Harbor will have to be designed to accommodate 60 per cent or more of the traffic being handled by trucks. The same ratio of truck traffic is being approached in San Francisco, Seattle, and Portland. If this increase continues it may mean the redesigning and rebuilding of every pier on the Pacific Coast, and will certainly mean the introduction into pier sheds of a far more comprehensive system of mechanical handling than at present prevails.

At least one new experimental machinery installation has been made on the Pacific Coast which may lead to a large introduction of such machinery. On the passenger and freight steamer *City of Honolulu* there has been introduced a conveyor system for handling general freight from side ports through hatches of the lower decks and into the hold spaces. Initial trips of this vessel indicate that this method of handling freight on combination passenger and freight steamers will be highly successful. Tests during the first trip indicated an overall saving of some 30 per cent as compared with ship's winches and tackle in the handling of pineapples in cases.

It is altogether likely that the development trend in materials-handling machinery at marine terminals for Pacific Coast use will have to be directed toward a condition catering to truck transport.

THE CERAMIC INDUSTRIES

For several years the common brick plants have experimented with cranes whereby they could progress the brick through drying and firing in units of from 2 to 500. This has involved the devising of kilns with removable crowns. In this system the bricks are kept in blocks of 2 to 500 throughout the process, even to the loading on to the cars or barges. The extension of this principle to brick manufacturing in general would result in great improvements and economies.

The most important development in pottery plants has been the tunnel kiln, in which the pottery products are fired while in constant motion through a long tunnel, the heat being applied at the middle of the kiln.

Other developments in materials handling have affected this industry chiefly from the standpoint of transporting the raw materials and unfinished and finished products by means of belt conveyors. Driers with automatic heat and humidity control and suitable conveying systems have come into use quite extensively.

The principal development of the future will be in the still greater application of continuous firing systems and continuous movement of the ware through the several processes, in the opinion of an authority close to the industry.

Summarizing, developments of note include:

Tendency to better organization within the plant for the control of materials-handling equipment

Tendency to handle heavier loads fewer times

Tendency to move material direct from freight cars to production machines instead of into raw-materials stores

Tendency to reduce the amount of work in process and the storage reservoirs of partly or wholly finished parts

Tendency to tie the materials-handling system directly into that used for production

Tendency to modernize facilities for handling in smaller plants, and in plants where comparatively low tonnages have to be transported.

Progress Report Committee of Division: HAROLD J. PAYNE, *Chairman*; GRAHAM L. MONTGOMERY; NIXON ELMER; M. W. POTTS.

Progress in Hydraulics

Contributed by the Hydraulic Division

Executive Committee: Ely C. Hutchinson, *Chairman*, H. L. Doolittle, *Secretary*, H. Birchard Taylor, R. L. Thomas, and W. M. White

THE YEAR 1927 has seen marked progress in practically all branches of industry related and of interest to the Hydraulic Division. The country as a whole has enjoyed an increased growth somewhat better than normal. While there has been no one thing outstanding, a review of what has happened during the year indicates a distinct trend.

The light and power industry in which the membership of the Hydraulic Division centers the greater part of its activity, is serving close to a million and a half new customers since the date of our last progress report. The greatest increase has been in the number of domestic-lighting customers. The increase in the use of industrial power and commercial-lighting power has nevertheless been well maintained and shows a healthy increase. In particular, the growth in the use of electricity in the rural districts is worthy of special mention.

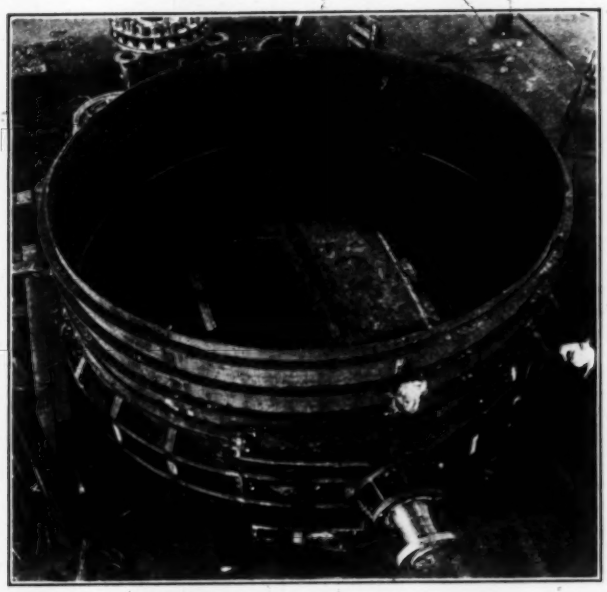
ECONOMIC AND POLITICAL ASPECTS

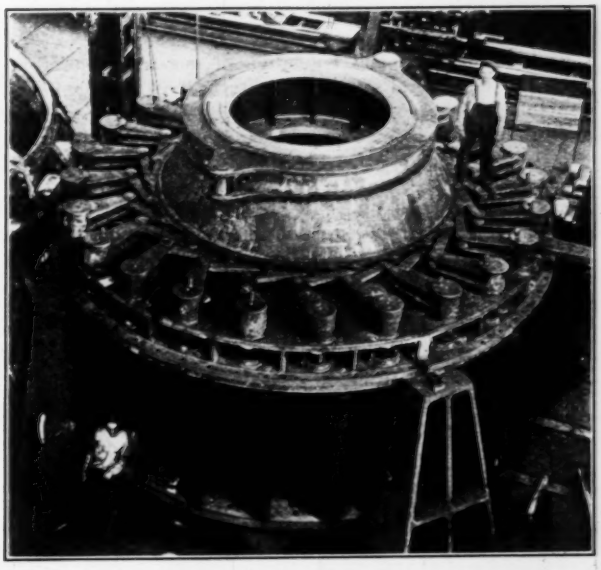
The economics of electric-utility operation is receiving increased attention, and one of the results of this is an increase in the interconnection of electric systems. There are now in fact eighteen electric systems in the United States each having an annual output of one billion kilowatt-hours or more.

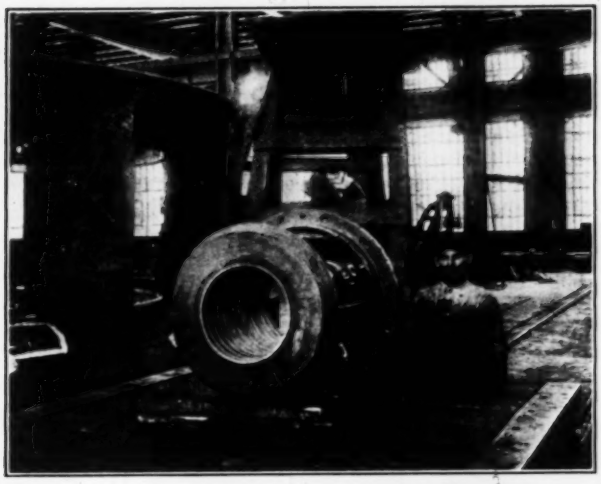
Increased efficiency in the operation of steam plants in combination with moderate- or low-priced fuels, has brought steam-power-plant operation to the point where in some cases it is economically the equal of, or superior to, hydro-generated power. While this condition has resulted largely from the fact that cheap water powers are becoming increasingly more difficult to find, it has also had the effect of introducing intensive economic studies as to the relationship and relative value of steam- and water-generated power.

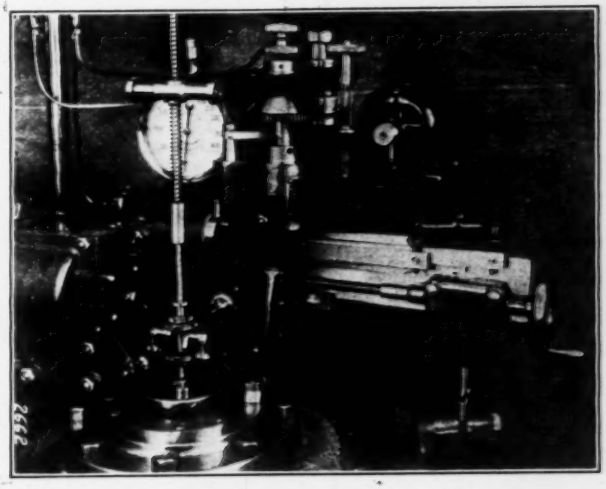
A number of studies by outstanding engineers have been published upon this subject during the past year under the auspices of The American Society of Mechanical Engineers; The Franklin Institute, Philadelphia; and The National Electric Light Association and its Pacific Coast affiliate, The Pacific Coast Electrical Association. A. H. Markwart, vice-president in charge of engineering of the Pacific Gas & Electric Co. of San Francisco, is the originator of an outstanding method for studying and properly evaluating the relative uses of steam and hydro power. It is the opinion of all students of the subject that the position of hydro power is economically difficult. Under the analytical method of Mr. Markwart, however, it becomes immediately clear that with certain relations between the capital cost of water power and fuel prices, although the cost of an all-hydro supply may be less than the cost of an all-steam supply, the cost of a combined hydro and steam supply is even less than the cost of an all-hydro supply; and conversely, with certain other relations, although the cost of an all-steam supply may be less than the cost of an all-hydro supply, the cost of a combined steam and hydro supply will be less than the cost of an all-steam supply. The practical application of these facts is apparent both East and West, and water-power developments are being examined from an enlightened economic viewpoint. A marked example of this is present in the U.G.I. installation at Rocky River, Connecticut. Eight thousand-horsepower vertical pumps have been installed for the utilization of off-peak power to elevate water to a storage reservoir for use in peak-load service. By this means a better balance of output is secured and a greater operating economy results. Although this plan of operation was used on a small scale very nearly twenty years ago in California and is quite generally used abroad, the U.G.I. installation is notable as being the first of such magnitude in this country.

It is very evident also that the economic position of hydro power is well understood and appreciated by the manufacturers of hydraulic-power machinery. Numerous studies in the engineering departments, laboratories, and in the field are being made by the leading manufacturers for the purpose of securing increased economy in hydro-power machinery. Results of this work will continue to be of untold benefit to industry and to the country as a whole. Work of this sort is, however, deplorably handicapped by failure on the part of a large number of central-power or public-utility companies to appreciate that the funds for carrying on such work must come from and be included in the sale of the machinery they purchase. Despite the fact that the prices obtainable by manufacturers for hydraulic-power machinery have been extremely poor, an effort has nevertheless been made to carry on their research and economic studies. Much greater advance would undoubtedly be made, however, and greater benefit will inevitably result, if some plan may be worked out between the purchasers and the manufacturers under which the manufacturers may be placed in funds as a result of their industry, with which to carry on their efforts upon a major scale. An exceptional few of the utility companies have practiced this policy, and no doubt know that the results secured have been ample recompense.









ABOVE: SHOP ASSEMBLY OF 27-FT. PIVOT VALVE, CONOWINGO DEVELOPMENT

BELOW : RUBBER-LINED GUIDE BEARING FOR 5000-HP. TURBINE

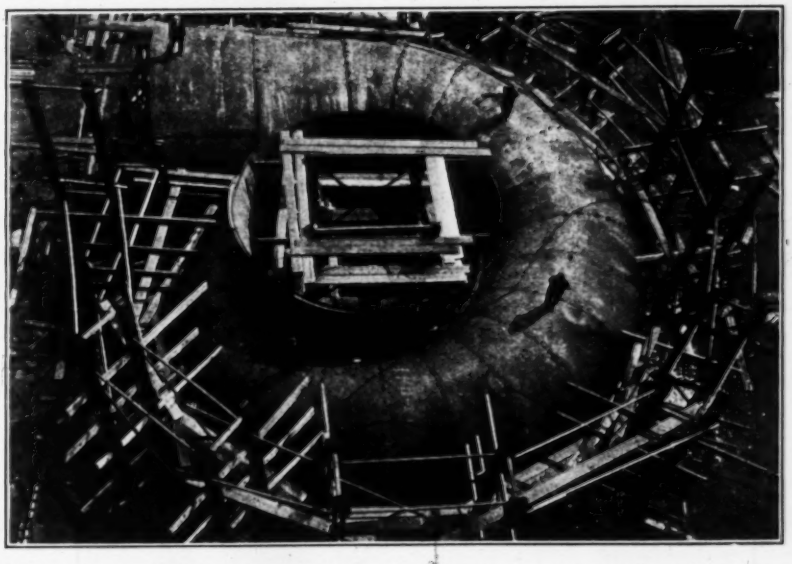


PLATE-STEEL VOLUTE CASING FOR 54,000-HP. TURBINE, CONOWINGO DEVELOPMENT

ABOVE: SHOP ASSEMBLY OF 54,000-HP. TURBINE FOR CONOWINGO DEVELOPMENT

BELOW: AUTOMATIC CONTROL FEATURES PROVIDED FOR 17,000-HP. PELTON WHEEL

The administration and regulation of our water-power resources by the Federal Power Commission have been generally acceptable to the people and accepted by the public utilities. The introduction of discussion and agitation in some directions toward interstate regulation of large projects such as the St. Lawrence, Tennessee, and Colorado Rivers is apparent.

The discontinuance of some municipalities in the hydroelectric-power field is noted, and their activities continue in some other parts of the country, notably in Los Angeles and San Francisco.

The findings in the so-called "Indianapolis Water Rate Case" are worthy of special mention. The Indianapolis Water Company, which is understood to be the third largest individual water company in the United States, brought suit to enjoin the Public Service Commission of Indiana, its members, and the City of Indianapolis from putting into force certain water rates on the ground that the fixed rates were confiscatory. The adjudication which followed and final decision which was rendered by the United States Supreme Court, November 22, 1926, is of special interest to the membership of the Hydraulic Division as it has set forth for the first time in the history of the United States Supreme Court definite principles having to do with the method of evaluating properties. The text of the entire decision is recommended to those who are further interested. The outstanding points, however, are contained in the following quotations from the majority opinion.

1 In determining present value, consideration must be given to prices and wages prevailing at the time of the investigation, and in the light of all the circumstances there must be an honest and intelligent forecast as to the probable price and wage levels during a reasonable period in the immediate future.

2 Re depreciation: The testimony of competent valuation engineers who have examined the property and made estimates in respect of its condition is to be preferred to mere calculations based on averages and assumed probabilities.

3 A reasonable rate of return is not less than seven per cent.

The opinion emphasizes also the necessity of including value of water rights, going-concern value, and working capital in a proper evaluation. Although it has been customary for some years for experts to give testimony of their own conclusions as to the proper rate or percentage of depreciation to be deducted in evaluation cases, such conclusions being based upon actual inspection by the experts themselves, it is believed that no former opinion has so emphasized the justice of this method. Because of the clarification of the entire matter of evaluations as a result of the opinion, it has been deemed advisable to make special mention of the case so that those further interested may secure the entire text for further study.

Substantially cognate questions are involved in the recent decisions in the Kansas City Gas Co. case and the still more interesting case of the St. Louis & O'Fallon Railroad Co. The entire matter is so important that there is no doubt that it will come, and probably within not too long a time, before the U. S. Supreme Court.

Improvements in Hydro-Power Machinery

A review of the year's progress does not bring special emphasis upon any outstanding mechanical improvement in hydro machinery. Intensive study has, however, been given to the improvement of existing designs in which advantage has been taken of operating experience. Knowledge of the comparative remoteness of remaining undeveloped hydro-power sites and their consequent high cost of development has given direction of thought among leaders of the industry to the necessity for simplification and economy of operation in hydroelectric installations. It is recognized that economy of plant operation is best secured with equipment which will operate most continuously and with the least expenditure for maintenance and renewals. To increase the existing knowledge, intensive studies are being made of the operation of power plants both steam and hydroelectric.

The outages of plants (or units), their causes, maintenance, and operating costs are being scrutinized and their relation to first cost of apparatus determined. In hydroelectric plants the economy of water consumption is receiving first attention. Air is being introduced into turbines automatically and otherwise, with the result that their no-load efficiency has been increased to a great extent when generators are floated on the line for the improvement of power factor. This method of operation has received much attention and its development has resulted in the elimination of a large percentage of stand-by leakage through turbines. It has become almost universal practice to make accurate tests of water wheels and turbines after installation to determine their operating characteristics. Information secured as a result of these tests is used to great advantage in developing the most economical method of plant operation in connected systems, the hydraulic conditions also being considered.

Voltages and frequencies are undergoing gradual standardization. This work must lead that of further and future interconnections.

The flow of streams that are subject to wide seasonal variations is being utilized to increased advantage by adding induced capacity to hydraulic turbines by means of backwater suppressors and ejector turbines. A great deal of attention is being paid to the improvement of turbine operation under variable heads. This problem has been more actively met in the European plants than in the United States, and instances of notable results secured have been published in the technical press. The most promising results have been secured in obtaining high efficiencies over widely varying heads by means of turbines having adjustable-bladed runners operated independently and in some cases automatically.

Propeller-type turbines are being successfully operated with stability and good regulation under increasingly higher heads, and efficiencies are ranging upward to ninety-two and ninety-three per cent.

Development of the use of rubber in various places is continued. Experience is increasing in the use of rubber seal rings for turbine runners. Rubber seals have been introduced as a means for decreasing the leakage around guide vanes when in closed position for the purpose of decreasing shutdown losses. Rubber is being applied to the periphery of large butterfly valves, and marked success is being secured in decreasing of water leakage by this method. Several cases are on record in which water-lubricated rubber bearings have been used with great success in turbines. Bearings of this type have replaced lignum vitae, with much better wearing results.

Much is being done to eliminate outage of hydroelectric plants from failure of the governor driving belt. Development in this direction is being manifest in the operation of the centrifugal elements of the governors by means of direct gear connection and electric motor. Other designs provide for mounting the centrifugal element directly upon the shaft of the prime mover.

Spiral casings for turbines which operate under moderate heads are being made of plate steel, with the joints in some cases being electric-welded in place at point of installation as means of securing more permanent water-tightness than by calking.

As a means of maintaining the turbine runner in its exactly central position, a hemispherical combined thrust and turbine guide bearing to the design of Albert Kingsbury may shortly be tried.

A measure of economy and increased reliability is being manifested in the electric welding of plate steel and rolled structural-steel forms into the frames or stators of large generators for which

castings of iron or steel have been hitherto used almost exclusively.

Means for maintaining a perpetual check upon hydroelectric-power-plant operation, both electrically and hydraulically, are being permanently installed in the power plants and are rapidly proving their value as an aid to the maintenance of the best operating efficiencies at all times.

The value of full automatic and semi-automatic operation of water-power plants is assured, and a great economy has been effected by their use. As a result, smaller water-power sources hitherto undeveloped or found to be very expensive to operate are being brought into service upon an economical basis.

OTHER IMPROVEMENTS IN HYDROELECTRIC-PLANT CONSTRUCTION

Of the improvements in hydroelectric-plant construction other than those which have taken place within the power house itself, several developments are worthy of special mention. The so-called "Johnson-Wahlmann intake" for admitting water into conduits is being installed. Its use is of special advantage in the avoidance of ice troubles at the intake and diversion works.

For high-head developments where the purpose of finding a suitable and safe penstock construction at reasonable cost has been a particularly vexing one, a solution has apparently been found in the development of centrifugally cast and cross-roll-forged seamless steel piping. The installation of expensive plant machinery for the manufacture of this pipe of high-grade steel in sizes from thirty-two inches up to any diameter which may be shipped, and in thicknesses varying from one-half inch up to five or even six inches, is assured and will undoubtedly mean much to the economic possibility of installing high-capacity, high-head, hydroelectric power plants.

In the case of tunnels lined with concrete a most important development has been that of the Hackley pneumatic apparatus for forcing concrete behind the forms of tunnels. This apparatus deposits the concrete without segregation and in horizontal layers in a very effective manner, up to and including even the crowns of the arches.

The fact that 220,000-volt transmission is now a demonstrated success as to reliability and economy, will undoubtedly mean much in the development of water-power projects which have hitherto been considered not economically accessible. Crest gates are being increasingly used as a means of maintaining the most economical hydraulic conditions for plant operation.

There has been wide development in the use of Johnson needle valves as an economical means for stream and storage-reservoir regulation. Valves of this type are becoming the accepted standard in this service.

THE BROADER POSSIBILITIES OF ECONOMIC HYDROELECTRIC-PLANT CONSTRUCTION

In the light of the present advanced-state of the art there is no doubt that there are numerous old plants operating in systems and under comparatively ancient water-power concessions that can well afford to be rebuilt or modernized. A study of such possibilities will in numerous cases prove to offer a handsome return upon the capital investment required. Another, and probably the source of the greatest opportunity for economic hydraulic power, lies in the complete and balanced development of entire streams and watersheds into a single project. There are probably numerous cases where the existence of isolated power developments has served to distract attention from the possibilities of a river or watershed which would be readily apparent if existing developments were removed from the picture. An effort should be made to uncover these and analyze their possibilities in the light of present-day knowledge.

RESEARCH

Research in the field of hydraulics is continuing in many directions. One of the outstanding projects in this respect is the Stevenson arch-dam investigation. This consists of an elaborate test upon a full-sized model arch dam made of concrete and having a height of approximately sixty feet, a thickness near the crest of about two feet, and a length at the crest of one hundred and sixty-five feet. This dam has been installed on Stevenson Creek, California, on the system of the Southern California Edison Co., under conditions comparable to those met in actual installations, and has been provided with means for scientific observations. The knowledge gained is already proving of great benefit. The work is being done under the auspices of the Engineering Foundation and is assisted by a notable group of contributors and cooperators, including the United States Bureau of Standards.

Research with the aid of small-scale models is increasing, and there are many notable examples of this, such as the Niagara Falls Power Co. model for the investigation of the proposed remedial works for the preservation and improvement of the scenic grandeur of Niagara Falls with the possibility of diverting more water for power purposes; the Chelan dam development of the Washington Water Power Co.; and the observation of surge-chamber phenomena at the Pit No. 3 development of the Pacific Gas & Electric Co. The Niagara Falls Company has undertaken extensive research in connection with its operations for the purpose of determining the friction losses in large concrete-lined tunnels.

Research is also being carried on for the enlargement of knowledge for the purpose of intake design; draft-tube construction; the determination of spiral or scroll-case forms for turbines; enlargement of the knowledge of causes of turbine-runner pitting, and many other live subjects.

A very constructive work has been done by Ray S. Quick in his analysis entitled "Comparison and Limitations of Various Water-Hammer Theories." The complete text of Mr. Quick's paper was read at the Spring Meeting of The American Society of Mechanical Engineers at White Sulphur Springs, West Virginia, in May, 1927.

A matter in which there is still much to be done is the investigation of the causes of corrosion in penstocks. It is hoped that this will receive greater attention than it has in the past.

CONCLUSION

The field of hydroelectric power is one of great promise and intense interest. The development of the market for electricity exhibits a healthy and encouraging increase. Activity in the works of irrigation and reclamation not only provides a market for electricity, but offers an inviting field to the builders of water-regulating and pumping equipments. There is vast opportunity for the users of hydraulic machinery of all kinds to cooperate with its builders and for the development of a purchasing policy which will give full recognition to the fact that the interests, aims, and desires of all are closely related. More complete realization of these mutual interests will inevitably lead to the greater progress for which we are all striving.

ELY C. HUTCHINSON, *Chairman.*

ACCORDING to Prof. H. T. Barnes of McGill University, Toronto, the waters of Lake Ontario lose 50 per cent of their heat in passing through the Thousand Islands owing to the many bays and rapids. The construction of auxiliary channels there to speed the passage of the water, he maintains, would render freezing impossible and leave the St. Lawrence open throughout the winter.

Progress in Fuel Utilization in 1927

Contributed by the Fuels Division

Executive Committee: John Van Brunt, *Chairman*, W. H. Wood, *Secretary*, Edwin Jowett, E. C. Schmidt, Victor J. Azbe, and R. T. Haslam

THE past year has been characterized by progressive development of equipment and methods previously introduced rather than by startlingly new innovations in fuel utilization. In practically every phase of combustion engineering this development had been rapid and well balanced, inasmuch as improvements have been made in practically all branches of combustion equipment.

This report is intended to review the more important features of fuel utilization in which progress has been made, both in the United States and abroad, during the past year and to indicate the most fruitful lines of research from which future developments may be expected to result.

The Bituminous-Coal Situation

Since bituminous coal is the principal source of energy for the generation of power, any interference with the supply is of universal concern. Early in this year it was apparent that a strike of the union miners was in prospect. During the first three months of the year every effort was made to increase the amount of coal in storage, and preparations were made to continue the operation of many of the unionized mines with non-union labor. When the strike did materialize, its effects were thus minimized to the point that there has been no serious depletion in stocks. Coal prices have increased, but not to excess, probably not over 10 per cent except in a few instances. Since agreements providing for resumption of work have been signed by the union miners in practically all of the states affected but Ohio and Pennsylvania, it is believed that the danger of a coal shortage has passed.

The monthly production of bituminous coal for the country as a whole has been slightly greater than consumption, and the cumulative output of bituminous coal up to the middle of October has been only 20,000,000 tons less than for the corresponding period last year. Production for the period January 1 to October 22 for the last four years is as follows:

Year	Tons
1927	426,149,000
1926	445,621,000
1925	400,621,000
1924	378,578,000

The consumption of coal by the groups using coal primarily for power production, i.e., the railroads and the central power stations, has not been materially greater than last year despite increased haulage and electrical output.

The data for fuel used and energy generated from fuel by central stations for the first eight months of 1926 and 1927 are as follows:

	1926 Jan.-Aug.	1927 Jan.-Aug.	Per cent difference
Energy generated in fuel-power plants (1000 kw-hr.)	27,452,249	29,556,431	+ 7.6
Coal used (short tons)	23,555,131	24,330,252	+ 3.3
Fuel oil used (barrels)	5,485,867	4,409,050	−19.6
Natural gas (1000 cu. ft.)	32,716,771	38,444,907	+17.5

The increased electrical output per ton of coal used indicates clearly the progress that is being made in fuel economy in power generation. It should be noted that the increase in the natural gas used is not the equivalent in B.t.u. value to that represented by the decrease in fuel oil consumed. The indications are clear that both the minimum and average figures for B.t.u. per kw-hr. reached in 1926 will be bettered this year.

Probably the most significant development in coal mining has been the rapid growth in machine cutting and machine loading at the working face. The output per man is constantly being increased by the use of machine-mining methods. Progress in other directions includes improved methods of washing and sizing coal and the use of larger mine cars. The use of coal-preparation methods continued to increase—consumers of both steam and gas coal being well aware of the advantages incident to ash reduction. These changes, however, constitute progressive development rather than radically new methods.

Stoker-Fired Furnaces

In the larger furnaces the trend toward the use of some form of water-cooled wall continues steadily, the principal advantages being reduced furnace maintenance costs and the securing of improved combustion conditions. The net effect results in increased capacity and efficiency.

The water-cooled wall is by no means a development of this year, but installations where both bare and refractory-lined walls have been made have now operated a sufficient length of time to permit definite conclusions to be drawn. These reports are apparently unanimous to the effect that water-cooled walls materially reduce furnace maintenance. The tests of such installations indicate lower ashpit and wall radiation losses. Rear walls constructed of refractories have been replaced with water-cooled walls with a resulting lessening of clinkering on the overfeed parts of stokers. Water-cooled walls generally result in lower stack losses. However, trouble is experienced in maintaining ignition with some coals at low ratings.

No decided swing to the use of either bare water-cooled walls or those protected with refractories is discernible since both types of construction have been freely used. In most cases the choice has been made on the basis of individual conditions in a given installation.

While many furnaces with air-cooled walls continue to be designed, many operators believe that this type of wall will be gradually displaced by the water-cooled wall for stations run at high capacity, despite the greater cost.

The use of carborundum refractories for the clinker zones of front, side, and bridge walls and the clinker pits of stoker-fired furnaces burning bituminous coal has proved to be excellent practice. They are also used in the side walls of chain-grate furnaces. The solid brick appear to be much longer-lived than are the perforated blocks, some of which have been reported to crack across the face, particularly when clinker is being removed.

The use of over-fire air injection with underfeed stokers, in one installation at least, has resulted in decided increases in overall efficiencies as well as in practical elimination of a bad smoke nuisance. The secondary air is admitted at the coking part of the fire, and a corresponding amount is eliminated from the dump end of the stokers. The efficacy of this application is dependent on the type of coal being burnt. A worth-while increase in efficiency was not found with the better grades of coal.

UNDERFEED STOKERS

Stoker designers have paid particular attention this year to the reduction of maintenance. Improvement in the design of details has been made in practically all types. However, there have been three major changes in stoker construction this year—increased length, improved air-distribution methods, and structural changes occasioned by the increases in length as well as to permit the use of more highly preheated air. The demand for higher evaporative rates and the more widespread use of water-cooled walls have caused a steady increase in the heat requirements per cubic foot of furnace volume. The result has been increases in length of stokers and use of water-cooled walls.

New stokers forty-five tuyeres long and more are being specified. Mechanical methods of speed regulation permitting a speed range of 20 to 1, which is far outside of the range of standard motor designs, have been developed. Better air cooling of parts exposed to heating has been provided, and extensive redesign of grate surfaces to permit the use of air preheated to 500 deg. fahr. and upward has taken place. However, the temperature of preheated air in the average installation does not exceed 350 deg. fahr.

Another development which has received much thought has been methods of securing better air distribution. The use of multiple air dampers has been extended. They are being installed for manual control singly and in groups. The efficacy of this device has been increased by the development of means whereby the dampers are interconnected in groups with the combustion-control system, thereby facilitating air control over the different zones of the stoker.

CHAIN GRATES

The developments taking place here are quite analogous to those made on stokers, the increased areas used being approximately 10 per cent over those of last year. Improvements in drive mechanisms have also been made, notably by the increased use of water-cooled driveshafts.

The introduction of secondary air through the arch has been successfully applied in chain-grate installations. It has cut down arch maintenance, improved combustion by reducing unburnt combustible, and, as might be expected, has produced no noticeable reduction in the radiation from the arch necessary for ignition.

On the theoretical side of furnace design it is believed that various papers presented to the Society should be of immediate value in simplifying the theoretical aspects of boiler-furnace design. Among the more important were those of Wohlenberg and Brooks, Hottel, and Haslam and Hottel. The treatment by the two latter of Schack's investigations has shown that the influence of gaseous radiation on heat transfer is much greater than has been assumed. These papers also indicate the progress made in developing a quantitative treatment of radiation from luminous flames.

PULVERIZED FUEL

The increased use of pulverized fuel, both for new equipment and in conversion of old installations, continues unabated. The analysis of the data in the 1927 Report of the Prime Movers Committee given in the next column clearly indicates the trend.

The remarkable increase in the use of the unit system during the past year is apparent. There are approximately 200 plants now using pulverized fuel where the size of the undivided units is 5000 sq. ft. of heating surface or over.

In the utility field no distinct trend toward either central-preparation or unit-pulverizer systems is apparent, whereas in the industrial field the unit pulverizer is largely predominant.

SQUARE FEET OF BOILER HEATING SURFACE FIRED WITH PULVERIZED COAL (OPERATING OR UNDER CONSTRUCTION)

(Cumulative data for boilers of 5000 sq. ft. and over)

	Central storage system	Unit pulverizers	Total
1923	1,097,634	194,472	1,292,106
1924	2,113,349	274,382	2,387,731
1925	2,981,597	585,088	3,566,685
1926	3,863,801	763,472	4,627,273
1927	4,432,975	1,522,460	5,955,435
Increase, 1926 to 1927	569,174	758,988	1,328,162

A paper by F. S. Collins with its discussion indicates the highly controversial character of this phase of combustion. Means have been found in both systems to handle coal successfully with a higher moisture content than formerly. The steam-heated drier seems to have been largely discarded for other types, no one of which appears to possess outstanding advantages. The success achieved in the use of preheated air in the unit pulverizer has helped to solve the coal-drying problem. Reports of successful operation with bituminous coal containing as high as 15 per cent of surface moisture have been made, but under these conditions the capacity of the mill is greatly reduced. The facts available also indicate the troubles experienced in the storage systems due to variable moisture content can be eliminated.

PULVERIZED-COAL BURNERS

During the past three years there has been increasing attention paid to the extension of the turbulence principle in pulverized-coal-burner design. During this year the actual installations of this type of burner have greatly increased over any previous period, due largely to the necessity for securing increased combustion rates per unit of furnace volume. This type of burner has also been found to permit reduction of excess air and to facilitate ash separation. In most instances it has been applied where water-cooled walls have been installed and where preheated air is used. Difficulty with some coals due to slagging of the lower tubes has been experienced.

PULVERIZING MILLS

The development of means of pulverizing coal to smaller-sized particles than at present will be an additional impetus to the further use of turbulent-type burners. There have been no radically new developments in this phase of pulverized-fuel utilization. Manufacturers are making some progress, however, in the construction of mills which will maintain uniform fineness of particle with constant output over the life of the grinding surfaces. Future progress must be to develop mills which will produce pulverized coal of increased but constant fineness over very long periods with constant power requirements and capacity, and yet permit of variations in moisture content, thereby avoiding the use of driers save in exceptional cases.

THE WELL-TYPE FURNACE

The application of the turbulence principle in powdered-coal combustion has been carried far in the Charles R. Huntley Station of the Buffalo General Electric Company, operating results of which are now available. The furnaces in the most recent group of boilers erected here are "composed of four water walls with refractory blocks extending down from the boiler to within a few feet of the basement floor. The lower section forms a well 15 ft. 7 in. square and 7 ft. 6 in. deep. Above this the two sides extend outward to the full width of the boiler." The total furnace volume is 10,200 cu. ft. The bottom is firebrick covered with dolomite. The coal and primary air are admitted through four burners, one in each water wall, each offset 4 ft. from the center line. The burners are of the Calumet type with openings 5 ft. × 2.4 in. The secondary air enters through ports on either

side of this opening. These ports are at an angle of 45 deg. to the primary jet. All of these openings are so arranged that tremendous flame turbulence results. Overall efficiencies in excess of 85 per cent have been reported. The units have a capacity of from 60,000 to 270,000 lb. per hr. This furnace construction permits, in fact facilitates, the use of coals with an ash fusion point of 1900 deg. fahr. The molten ash is tapped out.

This station is a stand-by, and this design has resulted in very low banking losses. By the use of tight uptake dampers the fuel requirements to maintain boilers at line pressure, while banked, average 150 lb. of coal per hour. The direct firing system is used. This type of furnace has probably not been carried to its ultimate design. Other similar furnaces have been designed and their future performance will be watched with a great deal of interest.

This year decided progress in the use of pulverized middle-western coals has been made, notably in central stations in Indiana, Illinois, and Iowa. Due to the high ash and low heating value of this type of coal the preparation costs are necessarily high.

The new Braunfels Station in Texas is probably the newest of the central stations burning pulverized lignite in daily operation. The moisture in this fuel is reported to be approximately 35 per cent, but it is largely chemically combined water which does not affect pulverization.

Gauger has reported that pulverized lignite burned at rates of 14,500 to 17,500 B.t.u. per hr. gave efficiencies comparable with those obtained with stokers operating on the best grades of lignite, and higher efficiencies than were obtained with low-grade lignites. It is certain that one of the principal advances made this year has been the successful use of low-grade fuels in pulverized form.

Pulverized Coal for Marine Boilers

What may prove to be the outstanding development of the year in this field is the equipping of the U. S. Shipping Board vessel *Mercer* with powdered-coal burners. The equipment consists of a preliminary crusher and unit pulverizers with turbulent-type burners. The ocean tests of this installation are now being carried out, and, if successful, may well cause extensive changes in marine-engineering practice. This installation was preceded by an extensive series of tests on a Scotch marine boiler fired with pulverized coal at the Philadelphia Navy Yard, during which combustion rates of 60,000 B.t.u. per cu. ft. per hr. for the entire combustion space were attained. The efficiencies varied from 70.26 to 77.06 per cent. Flue dust and cinder losses varied from 6.43 to 11.16 per cent.

Boilers

The detailed trends in boiler design have been covered in the report of the Power Committee. Certain of these trends, however, vitally affect fuel utilization. The most widely used steam pressure is in the neighborhood of 400 lb., and steam temperatures of 700 to 725 deg. fahr. are usual. Operating results of the high-pressure units at Edgar and Milwaukee have shown fully the expected economies. A second 1400-lb. unit has been added to Edgar, and a unit to operate at this pressure has been ordered for Kansas City. Probably the greatest single need in this particular field is further development of feedwater regulators.

The present tendency not to exceed steam temperatures of 750 deg. fahr. probably does not constitute the operating limit. In oil-refining practice mild-steel tubes are widely used at temperatures of 900 deg. fahr. and upward of 900 lb. pressure. Research now being carried out on metals at these conditions should be productive of results which will safely permit the use of steam temperatures in this same range.

Two-Fluid Systems

Another mercury-steam unit of 10,000 kw. capacity is being installed at Hartford. The special mechanical difficulties incidental to this type of unit seem to have been overcome. Despite the technical advantages inherent in the Emmet units, a rapid extension of these plants may not be anticipated immediately on account of the scarcity of mercury as is shown by a recent report from A. D. Little, Inc. It is pointed out that if the mercury-steam turbine were to take care of an assumed new generating requirement for the electrical industry of 2,000,000 kw. per annum, about 10,000,000 lb. of mercury would be required. This figure would be five times the present total consumption of mercury for all purposes in the United States. It is estimated that under these conditions the price of mercury would be prohibitive. It is not now apparent wherein methods of mining mercury can be developed to an extent which would produce this quantity at near the present price.

The possible use of high-boiling organic compounds of the type of diphenyl oxide as substitutes for mercury in a bi-fluid system has been indicated by Dow and others. Once the thermal stability of these compounds under operating conditions is assured, development of prime movers employing these compounds may be expected.

Locomotive Practice

In this field also no really startling developments have taken place, but the construction of more powerful and more efficient locomotives continues. The tendency toward increases in steam pressure and temperature, grate area, and furnace volume is quite apparent. Over 20 per cent of the locomotives in service are equipped with mechanical stokers; about half of the total number have superheaters installed, and more than this number are provided with automatic fire doors.

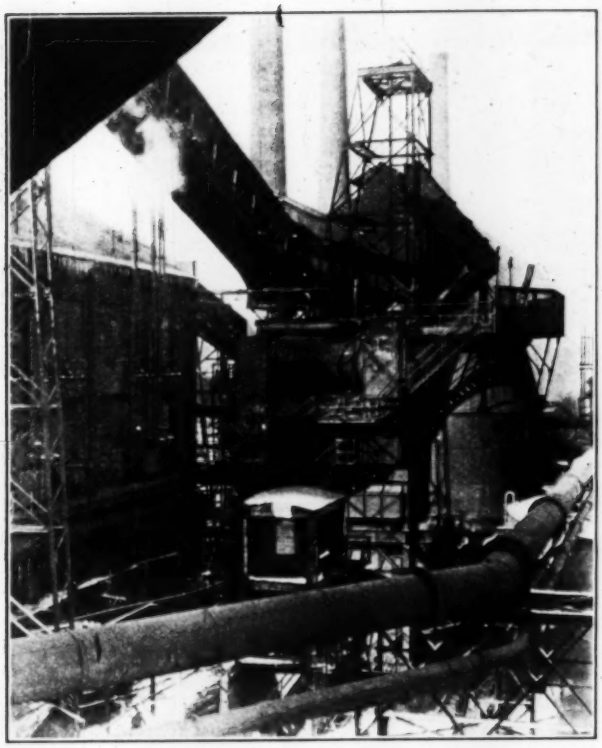
Comparative fuel data for 1926 and 1927 are not available, but it is known that a substantial reduction in fuel per ton-mile has been made during this period. Part of this reduction at least is due to selection of better coals and to the education of the mine owner to the fact that adequate methods of coal preparation must be employed.

Low-Temperature Carbonization

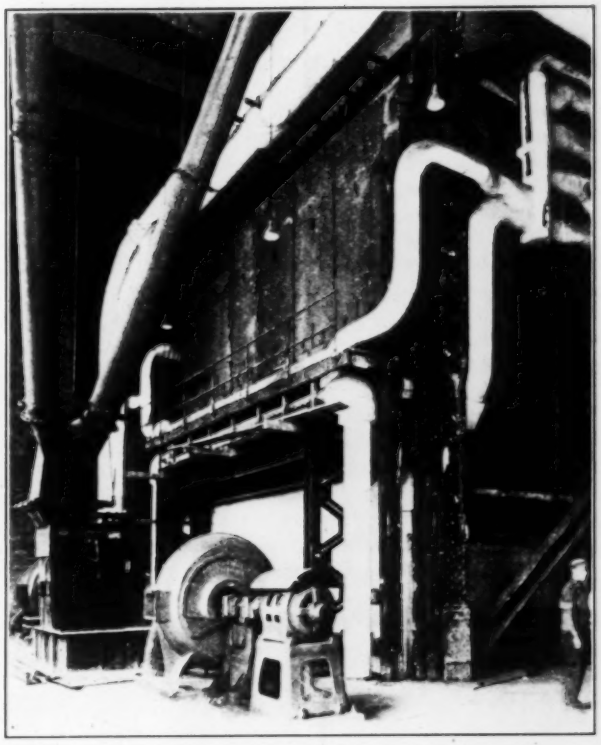
Probably the outstanding development in this field this year has been the announcement by the International Combustion Engineering Corporation that a K.S.G. plant would be erected for the purpose of furnishing gas to the Public Service Company of New Jersey and coke for domestic use. This process has been markedly successful in Germany and is extremely flexible as to the types of coal it can process successfully. Large-scale tests on American high-volatile coals have given yields substantially as follows:

	Quantity	Per cent
Semi-coke (12 per cent volatile)	1474 lb.	73.7
Tar	25 gal.	11.0
Gas (800 B.t.u. per cu. ft.)	3500 cu. ft.	9.3
Light oil	3 gal.	1.0
Water	..	5.0

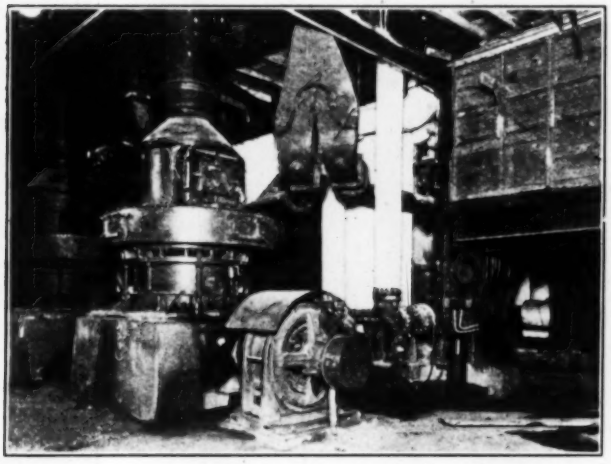
Previous to the announcement that the K.S.G. process was to be operated on a commercial basis, it had been felt by many engineers that the principal field for low-temperature carbonization processes in the United States lay particularly in the Middle West, where the low-grade fuels available are not susceptible to long storage without deterioration in heating value and in physical structure. There have been available, more-



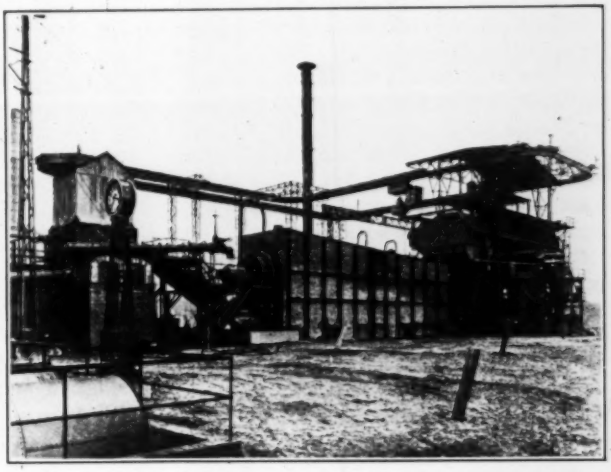
DRY-QUENCHING PLANT, ROCHESTER GAS AND ELECTRIC CORPORATION, ROCHESTER, N. Y.



VIEW OF BOILER AT CHARLES R. HUNTLEY STATION SHOWING AUTOMATIC SCALES AND MILL EXHAUSTERS



PULVERIZING MILLS AND FEEDERS FOR MILL-TYPE FURNACE AT CHARLES R. HUNTLEY STATION



GENERAL VIEW OF A TYPICAL LOW-TEMPERATURE COAL-CARBONIZATION PLANT

over, large quantities of mine waste at a price which would permit of a sufficient margin of cost in processing. Many processes have been worked on, notably the Parr, Green-Laucks, Stevens, McIntyre, and Carbocite, among others. None except perhaps that of McIntyre, who has been using West Virginia coal, has definitely reached the commercial stage. The development of the Parr process has been active this year, but work on the others has apparently been less vigorous, due perhaps to the disturbances in the middle-western field consequent on the strike. At any rate, results of a startling nature are not available. It is believed that the progress of the McEwen-Runge process at Milwaukee is being continued to a successful conclusion. This process is of especial interest because of the possibilities it holds forth for the combined gas and electric central station.

In England arrangements have been made to erect in a gas plant a full-scale set of low-temperature carbonization retorts which have been developed by the Fuels Research Board. Both this installation and the K.S.G. plant referred to above are intended to operate on a strictly commercial basis, and operating results will be awaited with unusual interest.

Domestic Fuels

The market for anthracite coal, particularly in New England, is being decidedly affected by the use of oil, coke, and manufactured gas for domestic heating. The state of the oil industry is such that furnace oil can be obtained at very favorable prices, and this, together with the active merchandising methods employed by many of the oil-burner companies, has led to a rapid extension of domestic oil-burning equipment.

The rapid increase in the use of oil for domestic heating is indicated by the reported consumption of oil for this purpose over the last three years:

1925	18,000,000 bbl.
1926	25,000,000 bbl.
1927	34,000,000 bbl. (estimated)

Where rate structures permit, the use of manufactured gas for house heating is undergoing steady growth. This fuel of course possesses probably the greatest advantages, aside from cost, of any domestic fuel, and further extension of its use may be confidently looked for as the gas companies can see their way clear to furnish it for such uses at rates approximating 70 cents per 1000 for 530-B.t.u. gas. The use of coke, particularly in those parts of the country where anthracite coal has hitherto been used, is steadily increasing, and the gas companies are paying a great deal of attention to the production of cokes most suitable for domestic use. It is now clearly recognized that coal gas is a base-load material, and the disposal of a part of the resultant coke as domestic fuel is now a necessary adjunct to the gas-manufacturing process.

The production of a briquetted domestic fuel from Rhode Island anthracite by the Trent process is now an accomplished fact on a small scale. The indications are that the extensive deposits of high-ash, low-volatile coal in Rhode Island and Massachusetts, hitherto regarded as unusable, will be made available, particularly in the adjacent territory.

Natural Gas

Natural gas, referred to in the past years as being in danger of rapid extinction, has come into much more extended use both for domestic and industrial purposes. The increased use of gas for power production has been indicated above. The discovery of new gas and oil fields has been responsible for this increase, and the extensive construction of new high-capacity pipe lines from the fields to distribution centers is steadily reducing the wastage of this fuel which has been prevalent. This wastage is still tremendous, but this branch of the fuel industry is making a concerted effort to regulate the production and distribution of natural gas.

The Petroleum Situation

This year (1927) has seen the maximum daily production of petroleum ever attained in this country, when the highest daily output was over 2,500,000 bbl. This flood of crude petroleum has been a very disturbing factor in the oil industry, and has led to a concerted endeavor by the larger producers to curtail production and stabilize prices.

Notwithstanding the large supplies of fuel oil made available, the greatly increased consumption of fuel oil for power generation which might have been expected has not taken place, undoubtedly due to the feeling that the supplies of low-priced fuel would be of such short duration that conversion to oil-burning equipment would not be economical.

Probably the outstanding development in the field of petroleum technology during the year has been the announcement by the I.G.F.A. in Germany that the Bergius process for the liquefaction of coal has been placed on a commercial basis. An extensive plant at Mannheim is reported to be capable of producing 1,000,000 bbl. of oil annually. The raw material used is German brown coal or lignite. The process consists in treating the lignite, which has been made into a paste with oil, with hydrogen at 1500 to 3000 lb. pressure and at a temperature of 400 to 500 deg. fahr. The lignite is largely converted into liquid products which when distilled give yields reported as follows: 15 per cent motor fuel, 20 per cent Diesel oils, 6 per cent lubricants, 8 per cent fuel oil, and 20 per cent high-B.t.u. gas. The rapid expansion of this process abroad may be expected, and its application in the United States as a means of adequately caring for any petroleum shortage apparently awaits only proper economic incentive. It is also apparent that this type of process possesses distinct possibilities in reworking refinery residues into motor fuel.

In the light of all of the facts it is difficult to be other than optimistic on the prospects for a continued ample supply of motor fuel of all kinds.

Dry Quenching of Coke

In the field of gas manufacture, much interest has been caused by the coke dry-quenching process installed at Rochester. A recent paper by A. M. Beebe states that the Sulzer process of dry quenching is the transformation of the sensible heat of the hot coke into steam at 140 lb. pressure, by circulating inert gas through the hot coke in a container and thence through a boiler. The design will doubtless be changed somewhat, but the results indicate the heat recovery of 69 per cent of the sensible heat in the coke. With coke at 1800 deg. fahr. and cooled to 400 deg. fahr. the steam production was 430 lb. per ton of coke. Taking all charges into account, the actual cost of steam made was 30.4 cents per 1000 lb.

The effect of applying this process to the by-product coke produced in this country would be startling. The total quantity of by-product coke produced in 1926 was 44,377,000 tons. Assuming that 70 per cent of this is under conditions where steam produced could be used effectively, the potential steam production by this process would be 13,300,000,000 lb.

Foreign Developments

Fuel Utilization. The majority of the large European stations recently contracted for are using the central-storage system of pulverized-coal firing, although numerous stoker installations have been made. Much of this development has been carried on by the European representatives of American manu-

facturers. The type of equipment employed does not differ materially from that used in the United States.

Upward of 30 per cent of central-station power in Germany is generated from brown coal. This coal contains 55 to 60 per cent of water and about 25 per cent of fixed carbon. It is usually burned on special inclined step-grate furnaces with hanging arches, although in the pulverized form is also being employed successfully. Further developments in this latter phase may be expected

Active and effective development of means for using low-grade fuels is being carried on in the larger European countries. This work has been accelerated by the miners' strikes, but has been prompted mainly by the economic necessity of using supplies of fuel near to the power stations.

Low-Temperature Carbonization. Many low-temperature-carbonization processes, due to local market conditions abroad, are operating successfully under commercial conditions. Units of the Maclaurin, Pintsch, Salerni, and Haul processes have been contracted for in combination with central stations. However, most of the installations made have had the production of smokeless domestic fuels as their primary aim, with motor fuels a secondary object. Except for the installation sponsored by the Fuels Research Board, no developments of particular commercial interest seem to have been made in England.

Thermal Storage. In an apparently successful attempt to obtain the high efficiencies and other advantages inherent in the maintenance of a steady combustion rate, the use of thermal storage in power plants is gaining increasing favor in European countries. Various modifications are being tried. In one type, water-tube boilers are connected to a storage tank maintained at boiler pressure. When the demand for steam is low the usual combustion rate is not altered and the feed to the boiler is maintained, the surplus hot water passing to the storage tank. When the load is above normal, water from the storage tank passes to the boiler.

With varying arrangements to suit specific conditions, this same principle is being applied in the United States in quite a diversified group of industries. One type of accumulator is described fully in another paper presented at the present meeting.

Use of High Steam Pressures. Probably the most interesting phase of this line of work abroad is the Benson boiler. A unit of 66,000 lb. capacity in operation and the construction of another of 300,000 lb. capacity is reported. A boiler of this type generating steam at the critical temperature and at 3200 lb. pressure has also been projected for locomotive work.

Other notable high-pressure boilers in Europe are those of Luloff at Amsterdam (650 lb.), Schmidt at Werangerode (870 lb.), the B. & W. boilers at Langerbrugge (750 lb.), and the Sulzer (1500 lb.) boiler. The large boiler with pressure about 485 lb. in using maximum superheat has come to be the rule in the large installations.

The numerous attempts which are being made to remove the boiler drum from the fire and evaporate the water indirectly are of decided interest. Notable among these attempts is the Hartman boiler at Cassel, where the evaporating is done by high-pressure steam generated in a coil boiler with small outside drums. This steam is passed through a coil in the main boiler drum to produce the major evaporating effect. Loeffler generates highly superheated steam in a coil boiler and then carries out the evaporation in a drum similar to a steam accumulator. Various other similar arrangements are being tried.

Among other interesting foreign developments on which there are as yet few data may be mentioned the Stratton furnace which burns crushed (not pulverized) coal in suspension, the Shultz vertical-tube boiler, and submerged-flame combustion.

High-Pressure Gas Distribution. The problem of large-scale production of manufactured gas and its distribution at high pressure over long distances has been attacked with vigor by the Coal Utilization Company of Essen. It is proposed to link the large producers of gas in the Ruhr in a distributing network by 450 miles of high-pressure pipe line with an intensive consuming district which at present is quite incompletely supplied with gas.

Rotary Furnace for Lancashire Boilers. In England the use of rotary grates in Lancashire boilers is a development of interest in view of the large numbers of such boilers installed. The fuel during burning is kept in a constant state of agitation. The advantages claimed include combustion rates as high as 150 lb. per sq. ft., adaptability to use of low-grade fuels, and low excess air.

RESEARCH

Fuels. This field is almost untouched at present. The opportunities for work, the result of which should be of great practical value are manifold. There is definite need for information on the effect of preheated air on the properties of solid fuels to be used as a guide in both stoker and pulverized-fuel operation. A start on the problem of the relation of ash constituents to clinker formation has been made by the Bureau of Mines, but much remains to be done. There is ample incentive for additional work on the effect of fineness of pulverized coal on flame propagation.

The McEwen-Runge and White processes for carbonizing coal in the pulverized form will doubtless lead to experimentation on this type of carbonization for many types of coals. A study of the coking and swelling constituents of typical American coals is being carried out. Several laboratories are now working on the conversion of coal into liquid fuels by various processes. The development of a simple process for utilizing off-peak water-gas capacity will be a real need of the manufactured-gas industry, as the extension of house heating with its severe winter peak develops into a substantial fraction of the yearly gas load.

The former aspect of future utilization of low-grade fuels has changed with the development of methods for their successful use in the pulverized condition, but much still remains to be accomplished.

Better methods of preparing coal for market have been developed recently, but additional development is quite possible and should be carried on energetically.

The necessity for continued work on unit pulverizers with the end in view of obtaining more uniform sizing with lower power costs is clear. A method of precipitating ash from flue dust simpler than that afforded by the Cottrell process would undoubtedly find application, particularly in the smaller plants.

Furnace Design. Distinct advances have been made in the theoretical treatment of heat transfer from furnace gases and radiant flames, but the surface has probably only been scratched. Work in this field is applicable to practically all of the industries utilizing and processing fuels. The methods of attack developed by Wohlenberg, Haslam, Hottel, and others recently should be actively extended. For example, the determination of the proper ratio of refractory to water-cooled surface in furnaces is still subject to investigation, as is also the determination of the actual laws governing the radiating characteristics of various types of flames.

In the motor-fuel field extensive research on new methods of producing better fuels for Diesel as well as automotive-type engines may be confidently expected. The vapor-phase cracking processes for producing motor fuel with a high anti-knock value will certainly receive much attention, and the present-day liquid-phase cracking processes are certainly subject to much

improvement. Work will undoubtedly be done on the better utilization of petroleum distillates for domestic heating.

Properties of Materials. It is believed that with the use of materials now employed, the upper safe working temperature and pressure limits are being approached. Radically new developments will probably depend on the development of alloys of greater strength and greater resistance to fatigue, erosion, and corrosion. The field for research on the properties of metals at high temperatures and pressures is most fertile.

The more extended use of water-cooled walls has not eliminated the necessity for continued research on refractories. The more extended use of the well-type furnace with coals of low-fusion ash has reintroduced the necessity for more work on the reactions between the various refractories and ash mixtures of variable composition at the fusion temperatures.

Organic Boiler Fluids. Sufficient work has been carried out thus far to indicate distinct possibilities in the substitution of organic fluids such as toluol (as proposed by Siemens-Schuckert) and diphenyl oxide for mercury in a bi-fluid system.

R. T. HASLAM,
J. T. WARD.

Progress in Oil- and Gas-Power Engineering

Contributed by the Oil and Gas Power Division

Executive Committee: E. J. Kates, *Chairman*, L. H. Morrison, *Secretary*, J. W. Morton, C. M. Manly, and H. A. Pratt

WHILE the preceding two or three years of oil-engine history were characterized by increasing compression pressures, 1927 has marked the beginning of what may prove to be a long struggle for higher speeds. The pressure increases that have taken place in recent years in several manufacturers' products were effected not so much with the aim for higher output as for the sake of convenience in operation. Cold starting was the object, occasionally also the elimination of water injection. As a result of this tendency, the low-compression or semi-Diesel engine which a few years ago represented the majority of oil-engine horsepower manufactured almost disappeared from the picture in 1927.

The present trend is unmistakably toward higher speed in order to obtain more power per pound of engine weight. The incentive is the conquest of the mobile field for the heavy-oil engine. The distinction of having attained the greatest recent progress therein belongs to the Diesel locomotive (4).[1]

DIESEL LOCOMOTIVES

From a timid beginning a few years ago, we have at present an established type of switching locomotive in the United States, used by at least ten railroads and several industrial companies with satisfaction and effecting considerable saving (47). Orders have been placed for at least three main-line locomotives by at least two railroads (24), and their construction is nearly completed. Two destined for the New York Central are being built in this country and have electric transmissions. One of them will be equipped with a 6-cylinder, 750-hp., 500-r.p.m. Ingersoll-Rand solid-injection engine, the other with a 12-cylinder, 800-hp., 325-r.p.m. McIntosh & Seymour air-injection engine. The one to be delivered to the Boston and Maine Railroad is being built by the Krupp Company, Essen, Germany. It is to be equipped with a 6-cylinder, 1300-hp., 470-r.p.m. Krupp solid-injection engine, and has gear transmission with magnetic clutches.

In Europe not less than 19 companies are engaged in the construction of Diesel-engine locomotives and rail cars. Several of them have achieved notable commercial success (4). At least nine locomotives of the Canadian National Railways have been fitted with Beardmore engines (33) of 400 hp., 750 r.p.m., using electric transmission. Some of them have been in use for over two years and have exceeded a mileage of 100,000 without a refit. The British Company is now building 12-in. × 12-in., 12-cylinder V-type engines developing 1200 b.hp. at 750 r.p.m. with an overload capacity of 1500 b.hp. at 900 r.p.m. The complete engine weighs 22,000 lb. or about 18 lb. per hp. Such an extremely low weight for this type of engine is a truly remarkable engineering achievement. Two of these engines giving a total of 3000 hp. are now being built in one large locomotive, giving a tractive effort of 100,000 lb. and hauling a 750-ton passenger train at 70 miles per hour.

Engines built by a number of German Companies (M.A.N., Deutz, Benz, Krupp), and also several Italian (Fiat and Tosi) and Swiss (Sulzer) companies have been successfully installed recently in locomotives and connected with electric, hydraulic, pneumatic, and mechanical transmissions of a great variety (15). Perhaps the most interesting foreign development is the direct-driven Kitson-Still locomotive (26), the double-acting engine pistons of which are driven by the internal combustion of oil on one side and steam on the other: the steam is generated by the heat of the exhaust gases. It is not so much the high thermal efficiency of this combination which commends it for locomotive use, as it is the flexibility which the steam provides (and which the internal-combustion engine lacks) and makes the cumbersome transmission unnecessary. The French Schneider works (4) is also building a locomotive on this principle and the trials on both are awaited with keen interest.

Out of at least 17 different systems of transmissions which are being tried for oil-engine locomotives, only the electric drive has proved itself beyond doubt so far, but the developers of the other systems are busy and it cannot be predicted which one will be ahead 12 months from now. In spite of the considerably higher first costs of the oil-electrics, operating experience gained in the last two years (45) shows that the Diesel locomotive is more economical to operate than the steam locomotive.

AUTOMOTIVE DIESELS

For automotive application still higher speeds and lower weights are required. Last year's progress in this field includes the new Junkers (23), Benz (3), Dorner (29), and the improved M.A.N. (23) and Peugeot (9) truck engines, scores of which have already been installed and sold in Europe. These engines have crankshaft speeds of 1000 r.p.m. and over, and weights of around 20 lb. per hp. A M.A.N. three-ton truck with a modified piston (Acro patent) and injection system is being demonstrated

[1] Figures in parentheses refer to references listed in the Bibliography.

here by the Robert Bosch Company (25), Long Island City. Its fuel economy is remarkable (about 0.6 cent per mile), while its flexibility and ease of handling leave nothing to be desired.

Among the other recent mobile and semi-mobile applications, the Caterpillar tractor, engined with a 75-hp., 650-r.p.m. Atlas Imperial Diesel (39), may be mentioned as a promising American development. High-speed engines recently developed by the Fairbanks, Morse & Company (40) [800 r.p.m., 12½ hp. per cylinder], Foos Gas Engine Company (10) [700 r.p.m., 80 hp. per cylinder], Cummins Engine Co. (42) [600 r.p.m., 12.5 hp. per cylinder], Bessemer Gas Engine Co. (43) and Hill Diesel Engine Co. (28) open the field for still wider use of the oil engine for dredging, excavating, road construction, small boats, and rail cars. The Treiber Company together with the American Brown Boveri Corporation are developing high-power light-weight engines, one of them being of the 9-cylinder radial type.

Besides those already mentioned at least six American companies, mostly manufacturers of gasoline engines, are, it is rumored, engaged in developing automotive oil engines, and we may be able to report definite accomplishments next year.

For aircraft application (2) the weight becomes of predominant importance. Although its higher thermal efficiency and reduced fire danger are in favor of the heavy-oil compression-ignition engine and its development is being pushed by the American and English governments, its use cannot become general before the engine weights are brought down to figures which compare favorably with those of gasoline engines. It may be added, however, that no principal reason is known why engines working on the Diesel principle cannot equal or excel carburetor engines in power output per pound of engine weight. On this continent the Attendu engine (6) [3.6 lb. per b.hp.] and the Sperry supercharged engine (5) represent promising experiments. Abroad, Junkers is planning on fitting his airplanes with his two-cycle, opposed-piston-type engines, and one of the new British dirigibles will be fitted with Beardmore engines, if rumor is correct

Giant Diesels

Looking at the other end of the picture, the progress made in high-powered Diesels is no less gratifying. Shipbuilders are the best customers for large Diesels. The increased popularity of the Diesel with ship owners is shown by Lloyd's figures. On September 30, 1,163,630 i.hp. of marine oil engines were under construction against 568,969 i.hp. of reciprocating steam engines and 309,900 hp. of turbines. Oil-engine tonnage increased to 52½ per cent from 19½ per cent four years ago. From a spectacular standpoint the most outstanding installations were single engines of the Doxford opposed-piston airless-injection type, 5000 screw hp. in four cylinders, in two single-screw vessels; and single engines of the Burmeister & Wain double-acting four-cycle type, 9000 screw hp. in eight cylinders, in three double-screw vessels. The latest set of these, installed in the *Saturnia* (44), is supercharged with two electrically driven turbo-blowers, which increases the output of each engine to 10,000 screw hp. The *Augustus* (35), the largest motorship in the world, 33,000 gross tons, equipped with four M.A.N. engines, 700 screw hp. each, has made her maiden voyage this November. The largest cylinder output ever attained was obtained this year from a Sulzer experimental one-cylinder engine, delivering 2900 i.hp. (46).

In this country several more Shipping Board vessels were converted into motorships (10). Nine main and 27 auxiliary engines were tested and delivered by six companies during the last fiscal year. Contracts have been awarded recently for the construction of eight more engines of about 4000 hp. to four different companies. Two are two-cycle single-acting, four are two-cycle double-acting, and two are four-cycle double-acting. The contracts are on the basis of $74 per b.hp., including scavenging blowers.

In the stationary field more high-powered Diesels are being installed in electric central stations. In the Commerce Mining and Royalty Plant in Oklahoma, three Nordberg two-cycle engines have been installed totaling 6750 b.hp. The favorable experience with the 15,000-hp. Diesel engine installed in 1926 for the Hamburg Electrical Works induced a Berlin electric-power company to place orders with M.A.N. for two 10-cylinder 12,000-hp. engines, 215 r.p.m. (21.3 ft. per sec. piston speed) to be used as stand-bys. America's largest Diesel power plant, the Panama Canal plant at Miraflores (27), consisting of three single-acting two cycle Nordberg engines and having a peak-load capacity of 12,375 hp., has been completed this year and serves a similar purpose.

Diesels for Peak Power

It is readily admitted that unless favored by particular local conditions, the Diesel engine cannot compete with steam and water turbines for large power generation. On the other hand, both calculations and experience have shown convincingly that their combination with steam and water power for peak loads and emergencies offers decided economical advantages (11). For short-period operations, the higher fuel cost of the Diesel is more than offset by its lower interest on first cost compared with water power and by its lower cost of keeping it prepared for emergency, compared with steam power. The water-power central station at Bremen installed two 3000-hp. Sulzer Diesel units to cooperate with water turbines. The 4500-hp. Diesel set of the Société des Forces Motrices du Refrain operates satisfactorily together with water and steam turbines. The possibilities of the Diesel engine for central stations are not yet fully realized (19).

Continuous Production

In medium-size engines, so far as design is concerned, no striking progress made in the last twelve months can be recorded. Many of the new models recently introduced in this country are licensed by foreign patent owners. Among the recent changes the popular adoption of the box frame and the improvement of the exterior appearance of the engines are most noticeable.

On the other hand, more and more engineering skill is being applied to production. Refined finishing methods are finding their way into Diesel machine-shop practice. Grinding and honing of cylinders, broaching of wristpin bushings, and lapping of spray needles, pump plungers, and even valve seats are used with success.

Larger builders have made progressive steps toward continuous production of engine units, using interchangeable parts, conveyors, and systemized material-handling methods.

The manufacture of small- and medium-size gas engines has lost its significance since the advent of the gasoline and Diesel-type engines. Where industrial gas is available as a by-product of blast-furnace and steel-mill operations, large gas engines are still most economical generators of power. The Allis-Chalmers Company is building gas engines in units up to 4000-hp.

Accessories

Many good accessories which have recently been placed on the market, either increase the usefulness of oil engines or relieve their builders from making such items themselves. Air and oil filters, centrifuges for lubricating and fuel oil, charging and scavenging blowers, distant-reading cooling-water and exhaust thermometers, and high-speed indicators are only a few of a worthy list. Fuel pumps and spray nozzles were not considered accessories until recently, yet at least one foreign and one Amer-

ican manufacturer are contemplating manufacturing these delicate engine parts and selling them to the oil-engine builders. Such a specialization in manufacture will probably further reduce the cost and increase the utility of the oil engine.

TREND OF DESIGN

While accurate figures are not easily obtainable, the trend is unmistakably toward hydraulic (solid) injection. Out of the total horsepower of stationary engines built in this country, 53 per cent was of the airless-injection type in 1924, 56 per cent in 1925, and 58 per cent in 1926, excluding the low-compression engines (3). In Germany and England this trend is still more pronounced. Hydraulic injection is not yet generally applied to the largest sizes, but Doxford and Burmeister & Wain have recently built airless-injection engines with 1250- and 1125-b.hp. cylinder capacities, respectively. It is being tried experimentally both on the Sulzer double-acting engine and on the Harland-B.W. design.

The struggle between two-cycle and four-cycle is still undecided. The respective figures for American stationary engines for the last three years are as follows:

	1924	1925	1926 (Estimated)	
Two-cycle.....	42	51	49	Per cent of total horsepower
Four-cycle.....	58	49	51	

In marine application the two-cycle seems to gain over the four-cycle, while for locomotives the opposite is the case.

The most spectacular advance, however, has been made by the double-acting principle. Not long ago double-acting engines were considered experimental, but now there are six different makes of double-acting engines in operation at sea and five more in a very advanced degree of development. Perhaps one reason why shipowners favor the double-acting two-cycle design is because it resembles most the familiar reciprocating steam engine.

As regards construction, a trend toward more rigid frames is noticeable. The A-frame is being displaced by the box frame with individual or cast-in-block cylinders. Rigid connections between the individual cylinders or cylinder heads frequently serve the same purpose. The reduced vibration and bearing wear achieved with the rigid construction justify the additional expense.

The chain drive of the camshaft, introduced not long ago, has won further adherents.

The use of aluminum and alloys for pistons is being tried with promising results. The use of high-grade materials for other engine parts together with refined finishing methods is also progressing, especially with high-speed machinery.

Efforts are being made to secure higher mean effective pressures for two-cycle engines. Crankcase scavenging is slowly losing ground, while the use of blowers is gaining for both charging two-cycle and supercharging four-cycle engines. At present the employment of blowers is restricted to large engines, but their introduction for medium and small engines is predicted.

In the controversy over direct spray injection as against a precombustion chamber, both parties are holding their ground, and no gain for either can be recorded.

New injection systems are still being introduced and a perplexing number of varieties are already available. Some of those recently developed take a middle place between the direct pump injection and the accumulator (common rail) system, by accumulating with each pump stroke only fuel enough for one injection, and using a mechanically operated valve for timing the injection.

The possibility of controlling turbulence by directing the intake air has been firmly established by the Hesselman, Krupp, Junkers, and Langley Field experiments, proving conclusively that the rotation of the air is not killed by the compression, German designers have already taken advantage of this fact, apparently with good results.

By supercharging with the Büchi system (45) using exhaust turbines for driving the blowers, the Swiss Locomotive Works has succeeded in increasing the rating of a four-cycle engine by not less than 50 per cent without any increase of the exhaust temperature, if reports are reliable.

RESEARCH

The oil-spray investigation of the National Advisory Committee for Aeronautics at Langley Field is yielding results. The subjects investigated lately and reported upon by the committee are: An investigation of the coefficients of discharge of liquids through small, round orifices, by W. F. Joachim (48); some factors affecting the reproducibility of penetration and the cut-off of oil sprays for fuel injection, by E. G. Beardsley (49); and factors in the design of centrifugal-type injection valves for oil engines, by W. F. Joachim and E. G. Beardsley (50). Experiments with various compression chamber designs (31) and novel injection nozzles are in progress, and favorable reports will probably soon follow.

As a result of the oil-spray research at the Pennsylvania State College (34) the development of an electric recording multi-diaphragm-type oil-pressure indicator has been reported (39), by which oil-pressure fluctuations of several thousand pounds taking place in a few thousandths of a second have been recorded and time-pressure diagrams taken.

Some experiments on oil jets and their ignition have been carried out by A. L. Byrd (17) at the University of Cambridge, using square orifices for injection of the fuel.

In Germany, elaborate investigations have been conducted for the determination of the globule sizes of atomized oil sprays. Kuehn counted the number of globules received on a smoked-glass plate, Sauter (21) used light absorption and also an electric charging method to determine the average size of the particles, and Wöltjen (2) injected the fuel into a non-miscible liquid of the same density and photographed the drops thus obtained.

The ignition of oil sprays has been investigated by Neumann (13) and Sass (41). The old dispute whether or not evaporation is essential for the ignition of liquid fuel, seems to be settled in favor of the latter.

Interesting temperature measurements on an Acro engine have been made by Stribeck (32). The interpretation of his results, however, is still the subject of lively discussions.

The Marine Oil Engine Trials of the Institution of Mechanical Engineers (20) have cleared in five reports many doubtful points in regard to the adaptability of the oil engine to ship propulsion.

The scavenging of two-cycle engines has received additional attention. Tests on a crankcase-scavenging engine have been reported by Holm (36). Many others are being kept secret.

Most of the investigations mentioned are being continued and further results are expected in the near future. The "secondary discharges" of automatic nozzles pointed out first by Eichelberg (14) and experimentally observed by Beardsley may clear up the problem of the so-called "after dribbling."

Investigations in the direction of increasing the speed and the m.e.p. are being quietly carried out in manufacturers' laboratories.

As to fuel economy, 0.354 lb. per b.hp-hr. has been reached (30), and 0.3 lb. per b.hp-hr. is being predicted by an English authority.

Of the researches in allied fields, the production of synthetic fuels and the nitration process invented by the firm of Krupp, by which steel on the surface is made as hard as quartz and not

deformed, may have important consequences on the development of oil engines.

ACTIVITIES OF THE INDUSTRY

Oil-engine business in general was not particularly brisk during the last twelve months. Production was kept up fairly well, but the profit sheets show a decline. Yet more and more capital is flowing into the industry due to the increased interest in Diesel engines. The Conversion Program of the Shipping Board calling for an expenditure of $25,000,000 gave a healthy impetus to the industry. Out of this sum $2,783,256 was spent in the fiscal year preceding June 30, 1927, and $2,290,300 worth of engines has been contracted since.

The Oil Power Week, held April 18–23 under the auspices of the A.S.M.E. and six other engineering societies, focused general attention on the production of power by the use of oil, by means of simultaneous meetings, discussions, and publicity. One hundred and six meetings were held throughout the country, and many valuable papers presented. The $100 Rudolph Diesel prize was awarded to W. F. Joachim of Langley Field Memorial Aeronautical Laboratory for his paper entitled "Oil Spray Investigations of the National Advisory Committee for Aeronautics" which was presented at the Oil Power Conference at The Pennsylvania State College, State College, Pa., and will be published later in the Oil and Gas Power Division's Quarterly.

THE NEEDS OF THE INDUSTRY

This report would be incomplete if it ignored certain handicaps the industry is confronting. Diagnosing a disease always helps to find the proper cure. It would perhaps be futile to deny that our oil-engine industry is not taking the place that it rightfully deserves. On September 30 out of 1,163,630 i.hp. of marine oil engines under construction in the world, only 13,090 were being built in the United States, compared with 365,440 in Great Britain, 244,370 in Germany, and 157,850 in Italy. It is true also that fewer ships were under construction in this country than in those mentioned, but certainly not less than in Switzerland. Yet Switzerland is building 6½ times as many (85,000 i.hp.) marine Diesels as we are. As stated before, 52½ per cent of the merchant vessels under construction in the world are motorships, but only 14.4 per cent of the American tonnage. With 76 per cent of the world's petroleum produced in this country, it is very safe to say that less than 10 per cent of the oil engines are made here. The 1926 exports in Diesel and semi-Diesel engines amounted to less than three million dollars, while in metal-working machinery it exceeded eighteen million. For other countries the proportion would be more nearly the reverse.

Production costs are high, selling costs are high, the competition of the electric-power companies is destructive, the power users have not sufficient confidence in oil engines—these are the explanations most frequently offered, but none of them is of such a nature that the manufacturers cannot do anything about it. A closer cooperation between the engine builders would accomplish a great deal in the direction of reducing selling costs and enlarging the market by an intelligent and systematic education of the power users as to the economic possibilities of the oil engine. Research, preferably cooperative research, would help to produce more efficient engines. We have heard from D. R. Pye, the English authority, just a few days ago that "a great deal of further research with the jerk pump is needed to place the designer in a position to know what are the characteristics of the jet he is producing." The cut-and-try method which is being practiced now is the most expensive of all, and will continue to be as long as we are in the dark as to the fundamentals.

Reduction in production costs could be achieved by specialization and adoption of modern production methods. The "part maker," a familiar figure in the automobile industry, has a justified place in the oil-engine industry as well. Few oil-engine builders are equipped to produce high-quality pistons, fuel pumps, and injection nozzles economically. Making fewer parts in larger quantities, we shall be able to adopt methods of quantity production: interchangeability, the use of jigs, fixtures and rapid-inspection gages; adopt continuous synchronized production, and do away with chalk and file and large-part storage.

The industry needs more trained men. In connection with oil engines, more than in most other fields, we formerly depended on men trained abroad. With immigration largely cut off, a shortage is being felt. A greater supply of skilled oil-engine operators would undoubtedly improve the market. Each competent operator helps to turn the sentiment in favor of the Diesel engine and is undoing some of the wrong done in the past by the many incompetent Diesel operators. We need more factory men skilled in erecting Diesel engines and machining delicate engine parts. We need more field service men able to diagnose troubles and give proper service to customers. We need more engineers trained in the design and developments of Diesel engines, men with sufficient theoretical background and some familiarity with the work that has already been done on the subject. Too often we see costly duplication of mistakes that could easily be avoided. Our technical schools do not give proportionate attention to the teaching of internal-combustion engines. If the oil-engine manufacturers would fall in line with the others in cooperating more closely with the colleges and universities, more emphasis would be laid upon oil engines and more students would be interested in the subject.

THE OUTLOOK

From this survey it appears that the outlook for the future is nothing but promising. The oil-engine industry, which survived in spite of the numerous handicaps, may look for something better if the handicaps are removed. Technical progress is satisfactory, and with intelligent effort it will be accelerated. A tremendous market is here, of which only a small fraction has been exploited so far. There is room for every one. We have little doubt that we shall see a spectacular expansion of the oil-engine industry in the near future. We wish that a happy and prosperous New Year may mark the beginning of it.

The undersigned wishes to acknowledge his indebtedness to all those companies and individuals that have submitted information and thus assisted in preparing this Report.

P. H. SCHWEITZER.

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Progress in Steam-Power Engineering

Contributed by the Power Division

Executive Committee: John A. Hunter, *Chairman*, V. M. Frost, *Secretary*, H. B. Reynolds, V. E. Alden, and F. M. Gibson

A GREAT increase in system loads and the more general use of large-size power-generating units have been important factors in making economically possible the notable achievements that have occurred during the past year. These achievements have not been confined to any one phase, but have taken place in almost all lines of the industry.

Although the use of large units has resulted in great operating economies, the principal reason for their use is to secure a lower cost per kilowatt of installed capacity. The economic use of large units has been furthered by extensive electrical interconnection. Additional efforts to reduce the plant investment have been evidenced by a desire to simplify power-station layout and design.

BOILERS AND BOILER AUXILIARIES

The trend in boiler development has been toward higher commercial efficiency. This has been secured by using larger units, higher pressures and ratings, water-cooled furnace walls, and automatic control. The demand for higher pressures has not caused any radical changes in boiler design. The manufacturers report that boilers for 1200–1400 lb. can be built to meet any code requirements without departing from the standard design except in minor details, such as forging the drums instead of riveting them. However, in some cases boiler design is being radically changed, as is seen in the extension of the use of the steam generator. Twelve of these units are either installed or under construction. As it is possible that this may

mark a turning point in boiler design, the performance of these units will be closely watched.

There has been little change of practice in coal and ash handling unless it is an increase in the use of sluices and dredge pumps for ash disposal. The practice of crushing certain kinds of coal and using a drag scraper in connection with the storage of coal to avoid spontaneous combustion is being extended. Considerable thought is being given to ash-handling systems for pulverized-coal-fired boilers. One company is reported to be experimenting with handling the ashes as molten slag.

The desire to maintain high ratings has resulted in greater application of water-cooled side walls and bottoms. Originally developed as a protection for ashpits and refractory walls of pulverized-coal-fired boilers, water walls are being used in connection with all types of firing. The surface furnished by these walls has proved to be such an effective and efficient heat-absorption medium that in some instances they are being installed for this purpose alone, the refractory protection being incidental.

Central stations are installing larger and larger boilers to avoid having an excessive number of units. One plant has a boiler installed that has sufficient capacity to generate all the steam required by a 50,000-kw. turbine. This increase in capacity is partially due to larger units and partially due to higher ratings. One station reports repeatedly maintaining an equivalent evaporation of 20 lb. per sq. ft. of surface for periods of six hours and over, and five other companies report having maintained evaporation rates of 14 lb. per sq. ft. of surface for short periods.

Indicating the demand for larger units, one of the Pacific Coast stations is installing two cross-drum boilers having a heating surface of 35,500 sq. ft. each. These boilers are the largest of their type yet built, and are designed to give steam at 460 lb. pressure and 725 deg. fahr. when evaporating 350,000 lb. an hour. The furnaces are to be oil fired and equipped with water-cooled walls. Another company is installing three units of the same type having a heating surface of 34,162 sq. ft. each. Several Stirling-type boilers, each having a heating surface of 41,500 sq. ft., have recently been installed, each unit being designed to supply sufficient steam to operate a 45,000-kw. turbine.

At the present time there are four boilers built for a pressure of 1200 lb. or over in service. The operation of these units has been satisfactory, and maintenance costs have not been higher than for the lower pressures. One installation operating at 1390 lb. has been in service for over a year and has given entire satisfaction. The growth in the use of high-pressure units is further demonstrated by the fact that two new boilers to operate at 1400 lb. have been ordered recently. These units of 1700 boiler hp. each are probably the largest high-pressure units undertaken to date.

However, boilers built for pressures of 1200–1400 lb. or higher can probably only be justified where the turbines they are to serve have a high load factor and where the fuel costs are moderately high. In the central stations in this country where these very high pressures are used, this is accomplished by the installation of high-pressure base-load turbines which exhaust at the main station pressure, the steam being reheated before being delivered to the main steam headers. All of the plants in actual operation in this country using reheat are equipped with special reheat boiler units in which the reheating is done by the products of combustion. Reheating by means of live steam is being given serious consideration, and the results obtained by the first installation, which is now under construction, will be of considerable interest. The first method probably results in the better plant cycle thermodynamic efficiency, while the second, due to lesser complication of piping and other similar factors, may lead to a better commercial plant efficiency.

There has been an increase in the use of temperatures up to 700 or 750 deg. fahr., but no unusual change in superheat temperature or design has occurred. At least one manufacturer is ready to offer superheaters to furnish steam at a temperature of 900 deg. fahr.

A tendency to use steam purifiers to safeguard the superheaters at the higher temperatures is noticeable. Application of the radiant-heat superheaters and convection-type superheaters, separately and in tandem, continues.

There is a definite increase in the use of air preheaters, the introduction of water-cooled walls being to a great extent responsible for this. Before the advent of the water-cooled wall the maximum rating obtainable was limited by the refractory materials used. This limit has now been raised, causing higher exit gas temperatures, and under these conditions the air preheater has been more widely used than the economizer. The regenerative cycle with its high-temperature feedwater minimizes the absorption of heat from the flue gases by an economizer unless it be of the steaming type. As present plans of one station call for heating the feedwater to 420 deg. fahr. by bleeding, the economizer appears to be still further handicapped.

The use of larger units has made possible the economic installation of full and semi-automatic combustion control. The problem of control is receiving more attention from combustion engineers, and is showing considerable progress. Several power stations have complete combustion control in operation, and maintain daily efficiencies very close to those obtained under test conditions.

METHODS OF FIRING

Pulverized-coal firing has continued its rapid advance in regard to the number and size of installations during the past year. At the present time over 45 public-utility plants are operating, or have under construction, sufficient aggregate pulverized-fuel boiler capacity to supply steam for a turbine load of 2,640,000 kw.

Many factors have contributed to this progress. One of these is the increased use of the unit pulverizer systems. However, their superiority over the central or storage systems has yet to be established, especially in central-station application.

Of more fundamental importance is the recognition of the necessity of properly mixing the air and coal streams. Another factor is the correct preparation of the fuel, such as uniform drying and fineness of pulverization. It is important that the fuel, primary air, and secondary air be thoroughly mixed immediately upon leaving the burners, so that combustion may be completed in a minimum of time and space.

It is upon the securing of these results that the future of pulverized-coal firing depends. While some engineers are of the opinion that pulverized-coal boilers will be the standard in the near future, it is apparent that no definite supremacy has been established as stoker development has been going on at a rapid pace. However, it appears that it will soon be difficult to burn sufficient coal per square foot on a stoker to develop the capacities required. This will be especially true in regard to central stations.

The increase in coal-burning capacity, due to pulverizing, has put the stoker manufacturers on their mettle, and as a result stokers of great size and fuel-burning capacity are available. Forced-draft traveling chain-grate stokers are made in sizes up to 525 sq. ft. of active grate surface, with a grate speed of 60 to 70 ft. per hr. The manufacturers claim these stokers will operate boilers at 500 per cent of rating continuously when burning midwestern coal. Underfeed stokers have made equally great progress. An eastern station is installing stokers with 45 tuyeres that will feed coal for a distance of 16 ft. in furnaces 19½ ft. from the inside of the front wall to the rear breaker

apron of the clinker grinders. Peak loads of 700 per cent of rating have been reached with this type of equipment.

Of even more importance than the increase in fuel-burning capacity is the use, by stoker designers, of every improved element which has contributed to advance the design of boiler units, including preheated air, water-cooled walls, and automatic control. It is significant that water-cooled walls with certain amounts of exposed refractory surface have been installed to an increasing extent during the past year, particularly in stoker installations used in the great central stations. Some of these installations can use air preheated up to 600 deg. fahr. These events constitute one of the outstanding developments of the year.

Steam Piping—Feedwater Treatment

During the past year the high-pressure stations have indicated a desire to simplify their piping systems and to eliminate, as far as practicable, duplication of piping with numerous cross-over connections, bypasses, etc. In a number of instances, stations using the regenerative cycle have substituted a bypass on the suction and discharge sides of the boiler-feed pump for the usual bypasses around individual heaters, and cross-connections between the heaters.

The American Engineering Standards Committee has just completed its report covering "Tentative American Standards for Steel Pipe Flanges and Fittings for Pressures of 250 Pounds and Above, and Temperatures of 750 Deg. Fahr."

There have not been any outstanding developments in feedwater treatment during the past year. Research and investigation have continued along practically the same lines as in the year previous.

A caustic solution containing sodium aluminate has become more widely used both as a coagulant and an accelerator in speeding up the reactions in lime-soda softening plants. Its use has materially reduced the total hardness of the treated water and at the same time has decreased the excess of reagents used in treating.

Improvements have been made in equipment for maintaining a desired sulphate-carbonate ratio in alkaline zeolite-softened waters. The use of this equipment is becoming more general in localities where natural high-alkaline waters are softened by the zeolite method.

Embrittlement of boiler steel is still the object of considerable research work in both this country and Europe. The investigation has resolved itself into studies of actual failures and laboratory experiments on the behavior of boiler steel when exposed to different-strength caustic-soda solutions.

Turbines

For several years the increase in size of turbines and generators has been very rapid. To date the largest turbine is a 208,000-kw. cross-compound unit now under construction. Although 1927 has not been notable for record-size units, one manufacturer is prepared to offer units of 300,000 kw. The largest single-cylinder unit in operation has a rated capacity of 65,000 kw. A single-cylinder unit of 75,000 kw. is being built, and a tandem compound turbine with a single generator rated at 160,000 kw. has been ordered.

Probably the most definite trend in turbine development is the marked preference of many engineers for still larger turbines of the single-cylinder design. As some of these engineers have previously been advocates of the two- or three-cylinder types, this development may have considerable significance.

A steam temperature of 750 deg. fahr. is still considered the limit for all pressures, but no doubt this limit will soon be raised as much research work is being done to determine the characteristics of metals at these temperatures. It seems only a question of time before sufficient data will be available to enable the temperature to be raised with the present materials or to secure the proper special alloy steels to accomplish the same result.

There has been a decided growth in the use of 1200-1400-lb. turbines and a still greater growth in the use of 600-650-lb. units. However, it seems to be the consensus of opinion that about 400 lb. steam pressure is probably the most economical pressure for a plant with a small load factor or a low-priced fuel. It has the additional advantage of being well adapted for operating in conjunction with higher-pressure steam or mercury vapor at some later date.

At present there is, either in operation or under construction, approximately 600,000 kw. of turbine capacity designed for operation with a steam pressure of 550 lb. and a steam temperature of approximately 725 deg. fahr. All of this turbine capacity is designed for a single stage of reheating to a temperature of 725 deg. fahr.

Practically all of the advantage resulting from the use of high superheat is due to its action in increasing the number of stages in which the steam remains dry. This is probably the chief reason why designers have either kept the pressure below the point where wet steam in the last stages becomes serious, or have used higher pressures and compound turbines with provision for reheating the steam between cylinders. If this reheating is done in the boiler room it requires large piping to and from the reheating boiler and also involves some loss in pressure which partially offsets the gain from reheating. One of the Chicago stations proposes to overcome this difficulty by reheating the steam near the turbine by means of high-pressure steam.

This will be the first American installation of a live-steam reheater. It will be used in connection with a 90,000-kw. cross-compound turbine, and will reheat approximately 500,000 lb. of steam an hour to about 470 deg. fahr. The chief objection to this method of reheating is the fairly low reheat temperature attainable.

Practically all of the power stations which have been placed in operation since 1923 have been designed for the regenerative cycle of operation with the feedwater heated by means of steam bled from the main turbine. Two- to five-point bleeding is still in favor. Operating experience has proved that the heating of feedwater by bleeding actually simplifies station operation.

Progress in condenser design has been along established lines and has consisted largely of increasing the physical dimensions and capacity. A condenser with 137,500 sq. ft. of surface is under construction which will consist of three units. One single-pass condenser with 85,000 sq. ft. of surface is being built that will require 135,000 gal. per min. of circulating water. This is probably the largest single-pass condenser thus far undertaken.

Some relatively new developments are gaining in popularity, including floating tube sheets, divided water boxes to facilitate cleaning, and hotwell construction that will cause violent ebullition of the condensate and thus simplify deaeration. There seems to be a noticeable decrease in the ratio of condenser surface to turbine capacity.

Motor-driven auxiliaries are in the majority, although in some instances their use has led to slight difficulties during times of electrical trouble.

The operation of boilers at higher ratings has resulted in an increase in the amount of power required for forced- and induced-draft fans in the boiler room.

Mercury Vapor

One of the most interesting power-station installations now in the course of construction is an addition to the South Meadow Station of the Hartford Electric Light Company. Following the

experimental work done in the Dutch Point Station, the Hartford Electric Light Company is now installing a five-stage 10,000-kw. mercury-vapor turbine which will take mercury vapor at approximately 70 lb. pressure and 884 deg. fahr. and exhaust it at 1 lb. abs. to two mercury condensers which are in fact steam generators producing steam at 250 to 350 lb. pressure. This steam is supplied to standard turbine generators. It is estimated that the complete installation will have a heat rate of 11,000 B.t.u. per kw-hr.

EFFICIENCIES

The year has witnessed an improvement in operating efficiency and the setting of new records in thermal economy. Probably the record thermal efficiency so far attained on a straight steam cycle is 27 per cent. The station establishing this record generates a net kilowatt-hour on 12,462 B.t.u., with a boiler efficiency of 87½ per cent, a coal rate of 0.89 lb., and a water rate of 7.85 lb. per kw-hr. These figures represent the average for an entire month. Although this achievement may be regarded as outstanding, the results obtained by many other stations have been almost as good.

INDUSTRIAL POWER

Many of the developments in regard to power generation in the central stations apply equally well to the industrial plant. Some of these changes have been modified slightly: for instance, in industrial practice, where pulverized coal is used the unit-type pulverizer has been the rule rather than the exception.

A decided increase in operating efficiency of many of the small plants can be seen. Some of the numerous factors that have contributed to this progress are: the employment of higher-grade men, the increased use of mechanical stokers, semi-automatic combustion control, larger grate areas, better records and instruments, improved furnace design, and a broader viewpoint of the problem as a whole.

Other contributing factors include the use of higher steam pressures and the increased use of relatively large turbine generators. Steam pressures up to 600 lb. are proposed for one installation, and several installations of 350 to 400 lb. are in operation. Two plants have boilers of 1200 lb. pressure that have been in service for almost a year. Turbines of 20,000 kw. capacity are the largest in use at the present time. However, a 30,000-kw. turbine is now being installed.

Industrial plants have improved their power costs by either putting their boiler plants on an efficient basis, generating their power with turbines having bleeder connections to furnish steam for process purposes, or by purchasing their power from public-utility companies.

There is a continuation of the work of enlarging and supplementing old boiler installations by building a new high-pressure section and using a turbine to expand the steam to the pressure of the old boilers. In some cases a reducing valve and a desuperheater are used instead of the turbine, and in still other instances where there is a demand for more steam than the reducing turbine can supply, a reducing valve and desuperheater are used in conjunction with the turbine. The results of this type of installation show considerable gain in economy.

An increase in the electrical interconnection of industrial power plants with one another and with public-utility power systems is noticeable. This arrangement gives all of the units connected to the system a better load factor and seems to have considerable possibilities, especially in those plants having considerable waste heat available for power generation and in which the supply of waste heat does not occur at the time of the electrical peak load.

JOHN A. HUNTER, *Chairman.*

Progress in Railroad Mechanical Engineering

Contributed by the Railroad Division

Executive Committee: H. B. Oatley, *Chairman*, Marion B. Richardson, *Secretary*, William Elmer, A. F. Steubing, R. S. McConnell, and Elliott Sumner

AS 1927 is the centenary of various railroad systems in this country, the recent and most elaborate celebration being that of the Baltimore & Ohio Railroad, it may not be out of place in this year's report to include a few figures which will briefly indicate the colossal proportions to which the American railway system has grown during the past 100 years.

The total investment in Class I roads now amounts to more than 24 billions of dollars; their mileage is in excess of 250,000, representing more than one-third of the world's total. On January 1, 1927, these roads operated 62,800 steam locomotives, which had an aggregate tractive power of 1,304,000 tons. As of the same date, these roads operated 2,350,000 freight cars which had a total carrying capacity of 105,717,000 tons. Over 1,000,000 cars were loaded each week during the year, and they carried 3791 tons of freight one mile for each inhabitant of this country. These figures give a background for an appreciation of the important place, in the economics of this country, which is occupied by our basic transportation industry. Lack of progress in development, and particularly in all of the engineering problems involved, would be a deterrent in the business and economic life of our nation. Such depressing effect, while it cannot be evaluated, would be admittedly enormous. A record of the progress which railway mechanical engineering has made, therefore, is always of value, and as the centenary of railroad beginnings is occurring, it becomes of more than ordinary interest.

During the past year the progress in railway mechanical engineering has been steadily toward bettering the operating efficiency of railroads by continuing the effort to increase the gross ton-miles per freight-train-hour. This unit is becoming generally recognized as a most valuable index. Part of the accomplishment is due to heavier and more efficient motive power, part to improvements in signaling, heavier car loading, etc.

"Railroad efficiency is a factor of national prosperity" has been a motto always in the mind of progressive railroad men. Efficiency in the purchasing and maintenance of stock material suitable for the requirements, but not involving an unnecessary investment, is an activity which, during the past year, has made marked progress. Intensive effort to avoid excessive surplus material has been made.

That some, at least, of the views expressed in previous reports of this committee have been brought into reality may be evi-

denced from the following quotation of a leading railroad executive:

> From the mechanical viewpoint, the most significant developments in the railway field are the design and construction of high-pressure steam locomotives, of oil-electric locomotives, and of very high-capacity electric locomotives; the application and operation of capacity- and efficiency-increasing devices to what may be called the normal type of steam locomotives, and the design and construction of locomotives of this same normal type so that they show more reliability in service, more economy in operation, and have a lower annual repair cost and a longer life.

The campaign for greater economy in the use of fuel, in which the International Railway Fuel Association and the Traveling Engineers' Association have been factors of great importance, has made progress during the present year.

The average daily movement per freight car for the first seven months of 1927 was 29.8 miles, the highest mark ever attained in any corresponding period, according to reports filed with the Bureau of Railway Economics. This was an increase of one-half mile above the best previous average established in the first seven months of 1926.

The campaign for greater safety, while not a mechanical-engineering problem, is of such intense human interest that endorsement of these efforts is not out of place in this report, and such endorsement is heartily given.

Progress in standardization of weighing equipment complying with the requirements of the American Railway Engineering Association and of the Bureau of Standards, has been reported as having made marked advancement during the current year.

MOTIVE POWER

The tendency toward higher steam pressures in locomotive boilers is going forward, the Delaware & Hudson Company having put in service its 400-lb. *John B. Jervis*, and the Pennsylvania is engaged in designing a 2–10–0 type with 450 lb. pressure. Auxiliaries are operated with superheated steam; enlarged grate areas, and greater firebox volumes are being used in increasing numbers, as are also feedwater heaters and exhaust-steam injectors. Three-cylinder locomotives are being bought in considerable numbers.

Experiments are still being conducted with oil-electric locomotives in switching service. The Chicago & Northwestern have added storage batteries in order to reduce the weight of the primary power plant.

The effort toward long locomotive runs is continuing, and in this effort larger tenders and a better spacing of water stations are proving effective.

Cast-steel underframes for tenders are being more extensively used, and experiments are being conducted with one-piece cast-steel locomotive frames and, on one road, with a cast-steel smokebox.

There is increased activity in and development of a modified boiler construction permitting more satisfactory service, not only for use with higher steam pressures, but with consideration of better water circulation and the reduction of corrosion effects. Consideration is also being actively given to the proper adaptation of condensing operation as well as to the use of air preheaters.

Reference to Table 1 shows the marked increase in the use of four-wheel trailing trucks on locomotives. It is to be noted also that practically all of the new and advanced designs of locomotives constructed during the year have had this feature, and also that a large proportion of the new designs have been built for steam pressures ranging between 220 and 300 lb. per sq. in. The tendency in this particular, mentioned in previous reports, has been progressing during the current year. A number of the new designs of locomotives have made use of nickel, or silicon, alloy steel for the shell plates of these higher-pressure boilers. Reports of the service of this material have not shown any indications of difficulties, and the advantages in reduced weight for a given set of conditions appear to have been realized.

Indications, from the records covering the first half of 1927, encourage the belief that the fuel savings on locomotives will amount to approximately $17,000,000 as compared with the year 1926. The consumption per 1000 gross ton-miles in freight service for the first four months of this year was less than for the corresponding period during the year 1926. If this rate of reduction is maintained, the 1927 figure will be 129 lb.

ROLLING STOCK

Experiments are being made with lacquers for both the exterior and interior finish of coaches and dining cars.

A number of railroads are putting motor buses on the highways as feeders to, as well as paralleling, their steam routes. Larger and higher-powered motor rail cars have been developed to haul one or two trailers.

The rapid advance in the use of self-propelled cars is evidenced by the fact that over 200 of such units were purchased during the first half of the year 1927.

The American Railway Association standard box car has been designed, and plans are being prepared for hopper and gondola cars. One road is experimenting with a solid cast-steel underframe for freight cars. Improvements in refrigerator cars involve trials of the "silica gel" process and "dry ice" or solid CO_2.

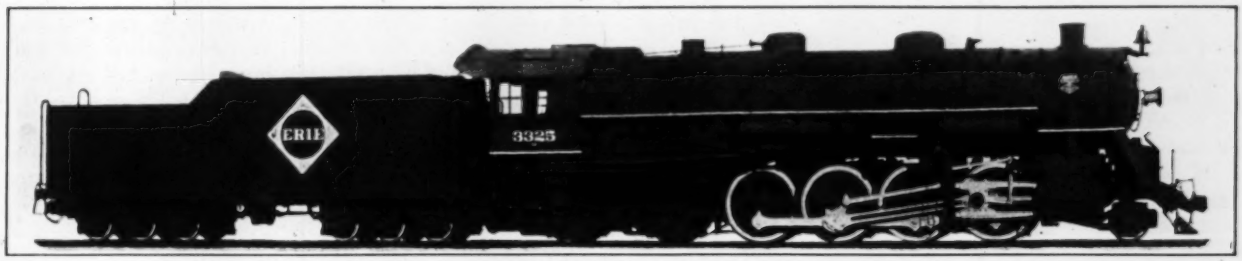
Automobile cars of new design, embodying side doors 12 ft. in width, have been built by the Chicago, Milwaukee & St. Paul, the Missouri, Kansas & Texas, and other roads, to meet an urgent demand from automobile manufacturers for cars with wide side doors, so that easier loading of completed automobiles is afforded. Reference should be made also to the 70-ton hopper gondola cars put in operation during the past year by the Delaware, Lackawanna & Western Railroad.

ECONOMICS

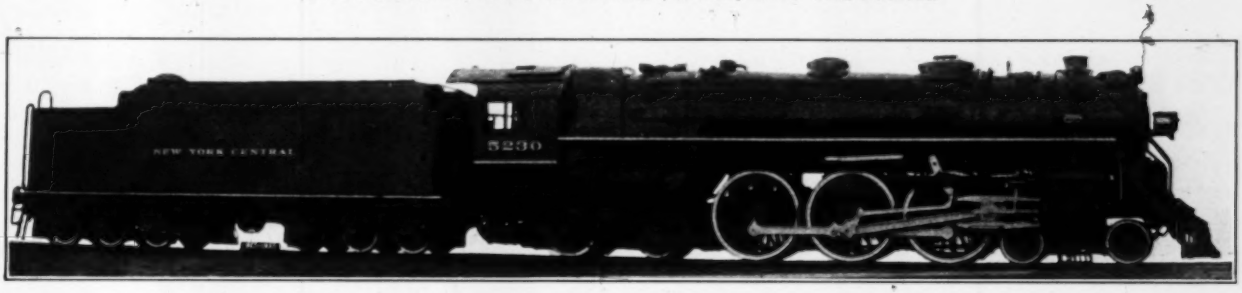
From the economic standpoint, we have the benefits realized

TABLE 1 DATA ON NEW DESIGNS OF LOCOMOTIVES

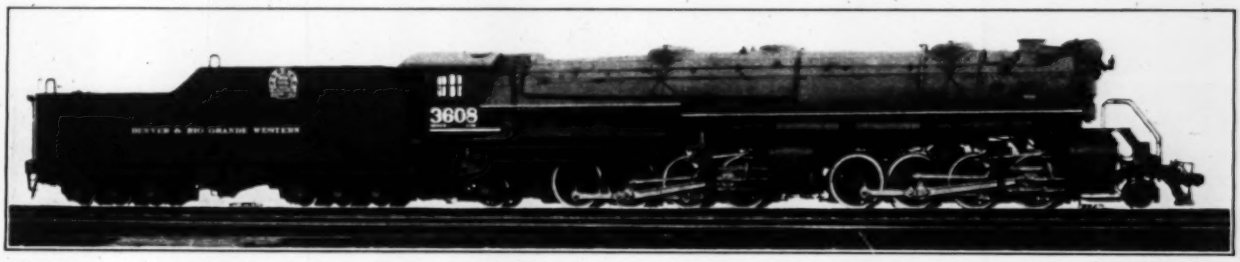
Road	Type of engine	Boiler pressure lb.	Cylinders No.	Cylinders Max. hp.	Type of superheater	Back-pressure gage	Feed-water heater or injector	Max. cut-off, per cent	Throttling between superheater and steam chest	Grate area, sq. ft. Total	Grate area, sq. ft. Per 100 hp.	Remarks
A. T. & S. Fe	4–8–4	210	2	3150	E	None	FWH	88	Yes	108.4	3.44	Mult. throt.
B. & O.	4–6–2	200	2	2252	A	None	—	85	No	66.7	2.96	.....
Can. Natl.	4–8–4	250	2	2705	E	With	FWH	85	Yes	84.3	3.11	Mult. throt.
C. B. & Q.	2–10–4	250	2	4000	E	With	FWH	65	Yes	106	2.65	Mult. throt.
C. & N. W.	2–8–4	240	2	2915	E	With	FWH	60	Yes	100	3.43	Mult. throt.
D. & H.	2–8–0	300	2	3121	E	With	—	75	No	99.8	3.19	.....
D. L. & W.	4–8–4	250	2	3036	A	With	—	85	—	88.2	2.9	.....
D. & R. G. W.	2–8–8–2	240	4	5100	A	With	FWH	70	Yes	136.3	2.68	Mult. throt.
Erie	2–8–4	250	2	3430	E	With	FWH	81	Yes	100	2.9	Mult. throt.
G. T. W.	4–8–4	250	2	2870	A	With	FWH	88	Yes	84.4	2.94	Mult. throt.
I. H. B.	0–8–0	205	3	2829	A	With	FWH	84	Yes	72.5	2.56	Mult. throt.
N. Y. C.	4–6–4	230	2	2580	E	With	FWH	86	Yes	71.5	2.77	Mult. throt.
O. I. M. Co.	0–8–0	235	2	2070	A	None	FWH	80	Yes	63.0	3.14	Mult. throt.
So. Ry. of Eng.	4–6–0	220	4	—	—	—	Inj.	—	—	33.0	—	.....



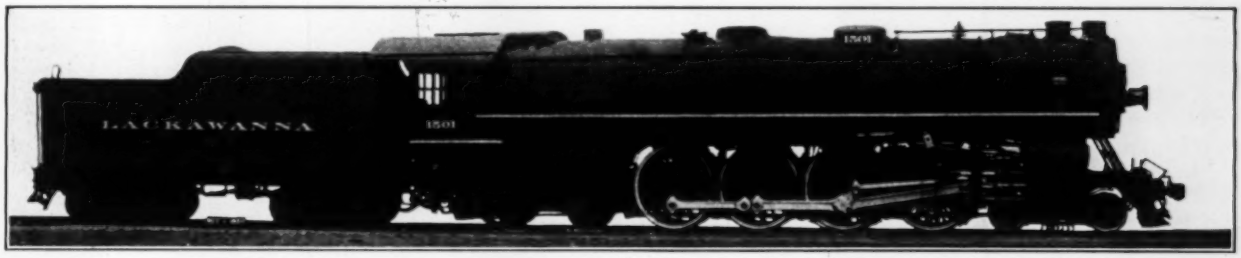
2–8–4 Locomotive Built for the Erie, and Equipped with Booster



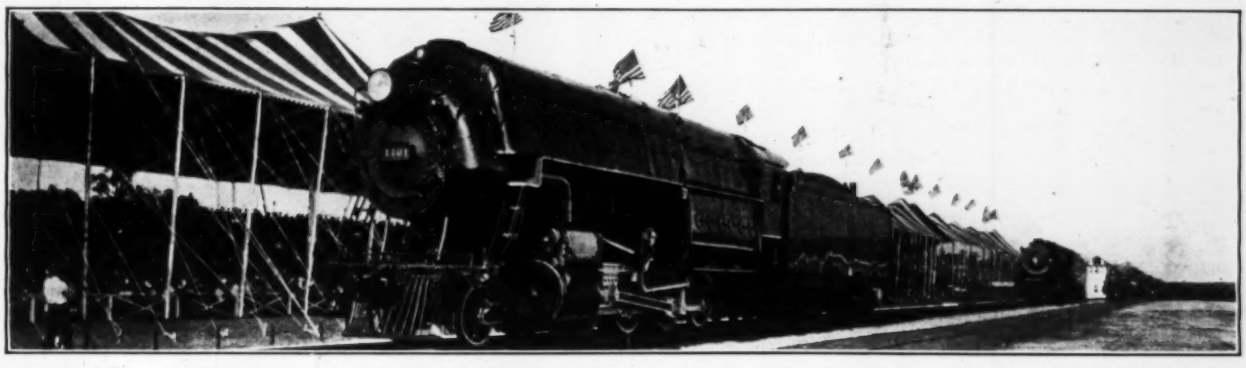
New York Central Locomotive of the Hudson Type (4–6–4)



2–8–8–2 Locomotive Built for the Denver & Rio Grande Western



4–8–4 Locomotive Built for the Delaware, Lackawanna & Western



The "John B. Jervis," a 2–8–0 Cross-Compound Locomotive Built for the Delaware & Hudson

by shippers and merchants because of the rapid and reliable movement of freight and passenger traffic; the rapidly increasing safety of travel, and especially the steadily decreasing net income of the carriers, which follows the many reductions in freight rates on the one hand and the alarmingly rapid increase in taxes and in payments to railroad workers on the other.

It is gratifying to note a change in public sentiment toward corporate interests, and particularly toward the railroads. A more sympathetic and appreciative viewpoint on the part of the public toward the progressive efforts of the railroads cannot help but have a beneficial effect upon all interested parties.

Greater efforts toward informing the general public of the engineering and operating progress is proving a wise move, and the railroad industry in general is to be commended for its efforts in this direction.

From the political standpoint, we have the growing political power of the standard labor unions; the desire of many politicians to stimulate railroad consolidation and to reduce freight rates, without regard to the cost of the service; and the thinly veiled designs of many to work toward Government ownership of the railways.

The increase in efficiency and reliability of the railroads, since 1920, has affected the every-day life of every individual. There have been no strikingly important changes in the machinery or processes during that period, although large sums of capital have been invested in the direction of modernizing and increasing the capacity of the railway plant.

Progress in extending the use of automatic train control, improved automatic signal systems, and more efficient operation in freight classification yards is also to be recorded for the year.

TECHNICAL TRAINING

Questionnaires were sent to all the technical schools and colleges that maintain courses designed to prepare students for railway-mechanical-engineering work. The replies show that the various educational institutions are beginning to feel the results of a greater effort on the part of the railroads and railway-supply companies to cooperate in the training of men for their respective industries. In addition, the American Railway Association has been utilizing the laboratory and test facilities afforded by the various educational institutions, especially at Purdue University.

The Pennsylvania State College has for some time been studying the problem of insulation and heat transmission, factors in the efficient insulation and cooling of refrigerator cars and the heating of passenger cars. Considerable progress in this work has been made in the past year.

A number of radical changes are being considered in the courses of study offered to students in railway mechanical engineering. For a number of years past different institutions have maintained courses in their curricula leading to the degree of Bachelor of Science in railway mechanical engineering. Among the most prominent have been the University of Illinois, Purdue University, Pittsburgh University, and The Pennsylvania State College. Some of these institutions abandoned the course a number of years ago and combined the railway course with the straight course in mechanical engineering, along much the same lines as the average course of study in civil engineering. Pittsburgh University, it is understood, and the Pennsylvania State College are, however, still maintaining a course in railway mechanical engineering. The latter institution, however, is seriously considering the abandonment of this course and including the more important railway subjects in its mechanical-engineering course.

In many respects this trend in railway-mechanical-engineering education will be beneficial from the standpoint of both the railroad and railway-supply industries. It is generally felt that mechanical engineers should have as broad an education as possible, and that specialization in college is not beneficial. It is also felt that a considerable improvement can yet be had in the educational field by a more careful selection of students in mechanical engineering, the installation of some scheme of vocational guidance, and the planning of the course of study to more adequately serve the mechanical engineer in railroad work dealing with steam turbines, gas engines, electric traction, etc.

The outstanding development in this field of education, from the standpoint of the railroad and railway industries, is the cooperative plan in engineering and commerce instituted several years ago by the Georgia School of Technology. The original plan of cooperative education for engineers was first instituted in September, 1920, when the textile department of that institution arranged a course, to cooperate with the cotton mills, in the education of textile engineers. Since that time the cooperative plan has been extended to a number of railroads; viz., the Central of Georgia, the Tennessee Coal, Iron & Railway Co., the Georgia Railway & Power Co., the Atlanta, Birmingham & Coast, and the Nashville, Chattanooga & St. Louis. Under the cooperative plan the student spends alternately four weeks in college and four weeks in mechanical-engineering work in the railroad shops at Atlanta, Ga., and the cities within a radius of about 300 miles. By this arrangement the Georgia School of Technology has available two courses in mechanical engineering: viz., the standard four-year theoretical course as given by other engineering colleges, and a five-year course for those students who wish to combine practical experience with technical theory. The cooperative course is under the administration of a director, an assistant, and an advisory board consisting of executives and officers of the various industrial and railroad companies with which the school cooperates.

The research work that is being carried on by the Railroad Division's Committee on Professional Service shows that the opportunities afforded in the railroad industry are comparable to those afforded in any other industry. In all probability there will be a larger number of mechanical engineers entering railroad work in the future. It is believed that an institution offering courses in mechanical engineering could offer a better-balanced course if the design and operation of motive power and rolling stock were included in the mechanical-engineering curriculum.

Considerable progress has been made by the Sub-Committee on Professional Service in collecting facts and information relative to the opportunities afforded the mechanical engineer in the railroad and railway-supply industries. A progress report was presented at the annual meeting in December, 1926, which included considerable data collected up to that time. That report was published in full in February, 1927, issue of MECHANICAL ENGINEERING. A second report will be presented at the Student Branch Meeting of the Metropolitan Section on March 14, 1928.

TREND IN DEVELOPMENT

Closer cooperation between technical schools, the railroads, and railway-supply companies is being evidenced. Technical schools more and more are requesting the services of mechanical engineers from the railway and railway-supply industries in bringing practical outside viewpoints before the undergraduates.

Aeronautical transportation, as an adjunct to rail transportation, has been given great impetus during the past year. Notice must be taken of the recent opening, by the American Railway Express Company, of its transcontinental air service, and the indications point toward an even more pronounced development in this field. Aerial transport coordinated with train service under railway-company operation, as well as by inde-

pendent companies, may confidently be looked for within a relatively short time.

Research and development work in insulation and heat transmission as applied to refrigerator cars and steel passenger cars will be continued, and rapid progress is anticipated.

Iceless refrigeration has been already developed to a point where its advantages in the railway field have been demonstrated, and its extensive use appears to be forecast.

Motor-truck and bus service has been extended. Particular attention is being given to determining conditions under which further extension, from the standpoint of economy and advantageous coordination with steam service, may be made. Mention must also be made of the increase in "auto-bus tours" as an adjunct to passenger travel. In this field the Atchison, Topeka & Santa Fe and the Southern Pacific are the best known. The indications are that there will be considerable increase in such auxiliary services.

The development of the Diesel-electric power units, suitable for rail motor cars, with a weight of engine and generator of not over 26 lb. per hp. has been brought to the Committee's attention. Light-weight units of this character and of a size and flexibility suitable for rail-motor-car use offer encouragement to the further adaptation of this equipment in the not-far-distant future.

Diesel-electric locomotives, arranged for multiple-unit control and suitable for road service, are under construction for the New York Central Railroad. The Ingersoll-Rand Company, the McIntosh & Seymour Corporation, and the General Electric Company are developing and perfecting this method of control.

The American Railway Association's draft-gear tests at Purdue University were started with encouraging results during the year. The same association has made progress also in its research into the question of truck side frames, and the results of this important work should, and undoubtedly will, prove of great benefit to the railroad industry.

Some attention has also been given toward applying mechanical draft to locomotives by using turbine-driven fans for forcing air below the grates. The question of the use of pulverized fuel also has received further attention. Definite reports as to the amount of progress which has been made along these lines have not been available.

Efficiency in the use of fuel, particularly as affecting the smoke-abatement problem, has been actively pursued and considerable progress reported. St. Louis is the center of the greatest activity in this subject.

The interest which the railways in the United States and Canada have in the application of roller-bearing journals has shown a marked increase within the last 12 or 14 months, particularly since the American Railway Association's Atlantic City Convention of June, 1926, at which time exhibits of trucks and other equipment thus fitted attracted no small amount of attention. Prior to this time several railways had been operating a small number of test cars. Within the last 18 months, four prominent trunk-line railroads have placed orders for 480 roller-bearing-equipped passenger cars of all types, all of which are now in service. The largest single order yet placed was for 133 cars. At the present time most of the other roads are disposed to watch the results obtained from the roller-bearing equipment in service rather than to proceed with any wholesale experimenting themselves. It is evident, however, that within the next year or two the manufacturers and the railroads will be possessed of useful data on the operating conditions of this type of bearing, as well as upon the relative merits of competitive types. Particularly is the latter true, as many of the operating advantages have already been well defined by actual tests.

The increase in size of motive power, the length of trains, and the larger-capacity cars now in use have brought about modification and improvement in draft gears which provide for the more severe service conditions. The problem of slack control in draft-gear design is another subject in which progress has been made. The much better condition in which air-brake apparatus is now maintained by the railroads is to be noted. Research in the air-brake field has been continuous and has resulted in the bringing out of a new type of feed valve having greater stability, reliability, and capacity, and a reduced cost in operation and maintenance. There have also been developments in brake-cylinder pressure-retaining valves and in the methods for more uniform application and release of brakes in passenger trains. The increasing use of higher steam pressures and higher steam temperatures has influenced development in air compressors and governors.

The increasing length of passenger trains has been appreciated by the manufacturers of train-heating equipment, and the past year has seen the application of train-heating equipment giving greater assurance that the rear cars of these long trains would be adequately heated. In this development, progress has been made in adapting modifications to the requirements of interchangeability between cars thus equipped and others.

The probable trend of development in the railway field within the next few years will be in the direction of enabling the railways to obtain a greater net income than has been the case during the last ten years. This increase in net income is necessary if the railway plant is to be enlarged so that it may, promptly and effectively, perform the work which it will be called upon to do, and, also to enable it to operate at a cost that its patrons can afford to pay.

BIBLIOGRAPHY

A bibliography will accompany this report when it is published later in quarterly form. While not complete, it is nevertheless believed to contain references to published information on most of the subjects covered in the Committee's report. It contains references to articles that have been suggested to the Committee by the various railroads and representatives of other industries which have favored the Committee with information, and appreciation of this cooperation is hereby acknowledged.

H. B. OATLEY, *Chairman.*

Solar Energy

THE so-called "solar constant" is the amount of solar energy impinging in unit time on a unit area placed perpendicularly to a sunbeam just outside the earth's atmosphere. By means of an instrument, known as a pyrheliometer, the mean value of this constant has been found to be 1.35×10^6 ergs per sq. cm. per sec. About 70 per cent of this energy passes through to the sea level if the air is free from dust and clouds. Since 7.46×10^9 ergs per sec. are equal to 1 hp., it follows that when the sun is at its zenith it supplies 4,690,000 hp. per square mile of illuminated territory, of which, allowing for the imperfect transparency of the atmosphere, about 3,000,000 hp. are available at the earth's surface. The maximum power output of Niagara Falls is estimated at about 4,000,000 hp. The total energy output of the sun divided by the solar surface gives 6.25×10^{10} ergs per sec. per sq. cm., which is equivalent to nearly 75,000 hp. per sq. yd. This output may be compared with that from a motor-car engine which on the average develops roughly 1 hp. per sq. in. of piston area, or only 1300 hp. per sq. yd. Per gram of the sun's mass, the energy radiated amounts to 1.44 calories per year.—Dr. J. Q. Stewart in *Journal of the Franklin Institute*, October, 1927.

Progress in the Petroleum Industry

Contributed by the Petroleum Division

Executive Committee: H. R. Pierce, *Chairman*, W. G. Heltzel, *Vice-Chairman*, P. L. Guarin, *Secretary*, Walter Samans, T. H. Kerr, and C. F. Braun

PROGRESS in the petroleum industry has its many ramifications, and the Petroleum Division in planning its review of this year's progress decided to subdivide its field and to request from a few prominent engineers a report on progress in their respective fields. The reports on these subdivisions contain valuable material that deserves the adequate treatment given by the authors, particularly because of the novelty of the matter treated and its paramount importance to several great branches of mechanical engineering. In view of this the Petroleum Division presents its Progress Report for 1927 as a symposium of reports of these subdivisions.

W. G. HELTZEL, *Vice-Chairman.*

Progress in the Production of Oil

BY HOMER R. PIERCE

THE producing formations have been getting deeper and as a consequence drilling and development methods have had to change very rapidly during the past year. The deeper sands, having a higher gas and hydrostatic pressure, deliver their oil to the drill hole at a much higher rate than shallower sands, and due to the greater quantity of energy per barrel of sand-stored oil, there is a greater percentage of the stored oil recovered and at a much more rapid rate of production.

Due to the nature of this stored energy, the drainage area of a well is enlarged so that the number of wells per unit area can be cut down, thereby reducing expense in drilling; but due to the same condition the drainage to offset production is greater, and lack of adequate line protection results in loss of one's potential production to a neighbor.

Due to the greater stored energy even with the wider spacing of wells, the oil enters the drill hole at a rapid rate, and its removal from the well at a higher rate becomes more and more of a problem. The old equipment used to remove oil entering from shallower sands fails to keep the column of oil down, and consequently the back pressure on the sand low, so that one's oil seeks his neighbor's outlet when and if the latter is holding a lower producing pressure on his sand.

To meet this condition there have been numerous long-stroke high-speed pumps developed and new kinds of swabs and bailing methods tried, but due to the extreme depth of the wells, crooked-hole conditions, and the large quantity of fluid to be lifted, as well as sanding and cup trouble caused by the high rate of flow through the sand, the above-mentioned methods have proved fairly expensive in the upkeep of physical equipment, and absolutely prohibitive in waste of time where offset production could be produced more rapidly, or continuously.

Air-Lift Method Best for Large Quantities of Oil

Consequently, the most successful and cheapest method of lifting large quantities of oil from great depth and under floating-sand conditions is by what is called the air-lift method. In some cases where the compressor equipment is installed and the wells properly tubed to give the maximum efficiency, production can be carried to its economic limit by this method of lifting, but in other cases it is necessary after the pressure in the sand has been drained to revert to the pump as a means of more completely depleting the sand.

These are problems which must be solved for each district, pool, or property, and in most cases for each well.

Some companies have realized that these problems are worthy of trained mechanical engineers, and are getting results comparable with their ability to pick engineers for the work and their ability to act on or judge the value of reports or advice of the engineers they employ.

Pool Production or Control Necessary

The high cost of drilling wells and keeping up offset production under the present competitive conditions, together with the resultant overproduction and reduced price, have made the substantial thinking heads of the oil industry realize that pool or unit operation or some method of control is necessary. This will in the near future allow of pool operation, which in turn will demand more engineering applied to production. That is, the pool to be operated will be analyzed and drilled with a view to the conservation of its natural energy, and with a future view of restoring energy to the sand at such a time and in such a manner that the greatest ultimate production will be had at a minimum expense per barrel produced.

This will mean that from the beginning the wells will be flowed in the most efficient manner; and, as it is necessary, the gas will be returned to the rock and used as an expulsion and lifting agent, and differentials across the sand and from the sand to the flow tank or gasoline plant will be regulated so that the maximum energy in the gas will be utilized.

Hard-headed business men in the oil business are fast becoming disgusted with the wholesale waste occasioned by highly competitive drilling and production methods, and once started on the warpath they will devise some means of improving conditions, because these men are today where they are, due to their ability to handle hopeless situations in a speedy and profitable manner.

When this time comes, as it soon will, the engineers are going to have more problems put up to them than they can handle. Therefore it behooves them to be preparing now for their future task. The ability to look ahead and prepare for the future needs is just as much engineering as the solving of the problems coming up from day to day.

The problems of producing large quantities of oil from deeper horizons do not confine themselves only to the designing of flow tubings and proper ratios of pressures, but necessitate working out better joints for the various ratios of tubings and the many strength-of-material problems entering into deep-well pumping.

Corrosion

Corrosion alone presents a wide field for investigation. Corrosion problems increase when handling deeper and more concentrated waters. This is especially true if air is used as a lifting medium.

Some of the deeper pools, which as explained deliver oil at a higher rate due to the excessive amount of energy stored in them, contain sulphur and other constituents which corrode metal very rapidly, and due to the fact that it is necessary to

remove this oil in order to keep pace with the production of neighboring wells as explained above, corrosion problems are in direct proportion to the rate of production.

Development of Mechanical Equipment for Petroleum Production

BY HOLLIS P. PORTER

THE progress of engineering in the petroleum industry has been very satisfactory during the past year. The greatest degree of improvement has been in the development of mechanical equipment, its application to the production of petroleum, and the handling and storage in field operations.

The air-gas lift has been applied very extensively to aid in flowing wells. This has been the cause of several new designs of semi-portable compressors driven by either multi-cylinder engines or electric motors. There are large, slow-speed units direct connected, being used for more permanent service.

PROBLEMS PRESENTED BY DEEPER DRILLING

Deep drilling has caused many problems to be presented to the mechanical engineer. In the Gulf Coast region at Spindle Top and other fields, deeper wells are being drilled. In California, an editorial in the September number of the *Oil Field Engineer* shows that in a list of some 391 wildcat wells drilled in 1925 and 1926 the depths ranged as follows: 98 wells between 4000 and 5000 ft., 71 between 5000 and 6000 ft., 21 wells over 6000 ft., and one well recorded at a depth of 7221 ft.

In the Mid-Continent and West Texas fields there is a great amount of deeper drilling between 4000 and 5000 ft.

As a result of deeper drilling, heavier machinery is being used. Batteries of three boilers to a drilling well, each boiler having a capacity of 100 hp. and a pressure of 200 lb., is now the practice. This can be compared with the use of two 45-hp. boilers for 125 lb. pressure, which was considered sufficient in most territories a few years ago.

The mechanical engineer is being called upon to not only design better and heavier machinery, but also to direct the way to better methods and more economic practices. The use of compound slush pumps which use 50 lb. of steam per hp-hr. compared to the present simple pump using 100 lb. of steam per hp-hr. will soon be common practice, but this must be carried farther by the adoption of a type of simple condenser, if steam is to be used for drilling. Electricity will replace steam where electricity is available for drilling, and gas engines will be used more for drilling as time goes on. These improvements are now being adopted rapidly, and the mechanical engineer is called upon to apply methods of economy to the production of oil the same as he has in the past in other lines of industry.

The development and operation work of the production departments have, in the past two years, added to the organization ten engineers and technical men where there was but one before.

Progress in Rig and Field Equipment

BY GLENVER McCONNELL

THE percentage of all wells drilled to depths of 4000 and 5000 ft. has increased very greatly during the past year. This has been accomplished by the use of more powerful machinery, a higher quality of tubular goods, and better selection of wire rope and transmission equipment. Aside from this, little effort has been made to introduce new equipment that is not built according to standard designs. Very little effort has been made to reduce the power costs, although there is some tendency to adopt high-speed bearings and to improve the lubricating systems.

Much improvement has taken place in equipment designed for greater power and speed in rig hoisting requirements. Manganese-steel sheaves, larger-diameter hoisting drums, stronger steel derricks and crown blocks, and many devices for better rope service have come into use. Now efforts are being extended toward improving belting conditions for heavy drilling and pumping machinery, and more attention is given to safety requirements. The industry has practically adopted the use of steel derricks, and it is predicted that the use of timber foundations will soon be a thing of the past. The influence of the A.P.I. program for the purpose of standardizing equipment in the oil fields has been a great aid and is increasing in its importance. Pipe and tool joints are being obtained which are made according to A.P.I. standards. The result of this is that a more uniform and safe product is in general use. If the A.P.I. committees do not accomplish anything more than to bring to light the glaring defects in equipment that has hitherto been considered satisfactory, the good that they will accomplish will be invaluable. As the engineers continue to study the ways and means for standardizing on such articles of equipment as belting, wire lines, manila cordage, pump specifications, and numerous other items, they are frequently forced to admit that heretofore too little was known of the mechanical requirements of drilling and pumping equipment. The choice of power-transmission equipment becomes more difficult when it is considered that the selection of electricity, steam, or internal-combustion engines is generally governed by the means worked out for satisfying drilling and pumping requirements. Two-speed-reduction machinery is being introduced satisfactorily in some districts for pumping, but it cannot be said that for permanent equipment or for standard purposes there is sufficient accomplishment for general adoption.

Requirements for drilling machinery less expensive to operate will necessitate more consideration on the part of oil-company executives to appreciate complicated designs and arrangements that are carefully engineered. Then, too, a system of instruction will be needed for all field men in the proper care and use of equipment. Many executives are loath to consider this, but it is generally realized by engineers that a great saving in operating costs cannot be expected unless basic changes are made in much of the rig machinery now more or less standard. Haste is too much the governing factor. Production at any cost rules the instinct of a successful operator. With this condition to meet, a larger and larger number of able men confine their efforts to improving the drilling tools, the well-head control devices, prime movers, rotarys, and a multitude of miscellaneous items from burners to sand pumps. In fact, it is difficult to keep a well-trained mechanical engineer in the field long enough for him to learn what basic changes are needed and to fit himself for the task of developing a more efficient system of drilling and pumping machinery in the face of more remunerative openings in the specialty field. But the industry offers a promising future to men who will hasten the time when it can be said that highly efficient means of drilling and producing oil and gas have been accomplished.

It is predicted that within the next twelve to eighteen months, when the overproduction now prevalent has ceased to exist, a great awakening to the needs of lower operating costs will be followed by such improvements in mechanical engineering in the oil fields that the gradual progress of the past will be looked upon as insignificant. The cry for competent engineers is beginning to be heard on every side. Their work in the field operating division of the industry will revolutionize present conditions.

Progress of the Natural-Gasoline Industry for 1926-1927

BY H. B. BERNARD

THE natural-gasoline industry during the past twelve months has had a tremendous impetus due to the development of new fields in California, in the Panhandle of Texas, and in Seminole and Pottawatomie Counties, Oklahoma.

The problems presented in new construction in California did not entail any novel features or anything of special interest.

In the Panhandle Field of Texas the high content of hydrogen sulphide in the gas processed in gasoline plants called for experimentation with and design of equipment to withstand the extremely corrosive action of the gas. To date the problems have not been completely solved, but great progress has been made by engineers and chemists of the industry. The gasoline produced from the gas necessitated the design of special equipment and the introduction of new processes for its treatment.

Under a recent arrangement between several operating companies in the Panhandle Field the natural-gasoline and the pipeline departments of the industry have cooperated to develop more economical methods for the transportation of crude oil admixed with natural gasoline. At this time the experiment is of short standing and consequently no results are available.

TWOFOLD USE OF AIR OR GAS LIFT

In Seminole and Pottawatomie Counties, Oklahoma, wherein is located what is known as the greater Seminole Field consisting of the Searight, Seminole, Bowlegs, Little River, and Earlsboro pools, the principal problem presented has been the use of the air or gas lift used, first, as a means used solely for producing oil, and second as a means for producing oil and extracting gasoline with the same equipment. As the equipment used for flowing wells and producing gasoline at the same time is practically identical with the equipment utilized for the more limited application, any summary may be confined to the twofold system.

Prior to the application of the gas lift to the production of crude petroleum, natural-gasoline plants of the absorption type had practically supplanted plants of the compression type due to the economic conditions involved and not due to the greater efficiency of the former, which is the common impression. In 1926 one of the major oil companies in the Browning Pool near Madison, Kan., constructed a compression gasoline plant built for the primary purpose of extracting gasoline but with two secondary objects in view, the first of which was to put gas pressure back on the sand, and the second to produce oil from the relatively shallow wells (about 2200 ft. deep) with the gas lift. This plant has been very successful and was the forerunner of the double application of compression gasoline plants.

Early in the history of the Seminole Field the first gasoline plants in that area were conceived (about August-September, 1926). These plants were universally of the absorption type, and made no provision for the production of high-pressure gas for flowing purposes. About sixty days later when several high-pressure compression plants using both air and gas were put n service, it was found that where gas was the medium compressed, gasoline was extracted, but as no final coolers were installed on the second stage, the gasoline production was very small. A short time later it became a more or less general practice to install an absorption-type unit on the discharge of the low-stage compressors to extract the gasoline, and this method is in more or less universal use in those plants constructed late in 1926 and early in 1927.

Considering that the condensing and cooling of a given amount of gasoline over a definite temperature range requires a given amount of condenser surface and with the view of eliminating absorbers, stills, and the numerous auxiliaries used in connection therewith, one of the major oil companies in March, 1927, put in operation a gasoline plant, designed not only to efficiently extract gasoline under compression methods but to furnish high-pressure gas for producing crude petroleum by the gas lift. Shortly thereafter this plant was put in successful operation, and it has set a model type of construction and operation which will replace the high-compression type of plant utilizing absorption equipment for gasoline extraction. One of the principal problems presented in the construction of the two-purpose compression plant was the design of a system of controls to enable the operation of each individual well under the most favorable conditions and to permit the "kicking off" of any well or wells without interference with other operations. This system was fully developed in July of 1927, and while it is undoubtedly capable of improvement, as the question now stands it is eminently satisfactory in operation both from the engineering and operating standpoints.

To permit the operation at normal pressures (250–300 lb. per sq. in.) for gas lift in the Seminole Field, and to provide for the same units to operate at 650 lb. per sq. in. for "kicking off" the wells, required the design of special cylinders, and the initial development of this equipment was found satisfactory. As the machinery is designed to operate fully loaded at the lower pressures, throttling devices on the suction for high-pressure operation have been resorted to.

The application of the principle of compression for a twofold purpose has resulted not only in economy of operation but has permitted the construction of large central plants as opposed to the construction of a number of smaller plants, with a corresponding further increase in operating efficiency and economy.

USE OF SUPERHEATED STEAM FOR POWER AND PROCESS REQUIREMENTS

During the past year superheated steam was used for the first time in natural-gasoline plants for power and process requirements. This development is too recent to permit reporting on its results. The use of marine-type boilers in three plants of one large operating company during the past year has shown splendid results, in which a high steaming rate has been combined with low construction, operating, and maintenance costs. The high furnace temperatures developed in this type of equipment, however, required a careful selection of refractory equipment, but this feature appears to have been successfully worked out.

The use of base-exchange and lime-soda water-treating systems has become more general than in previous periods, as has the application of automatic controls not only in the power plant but in the process equipment as well.

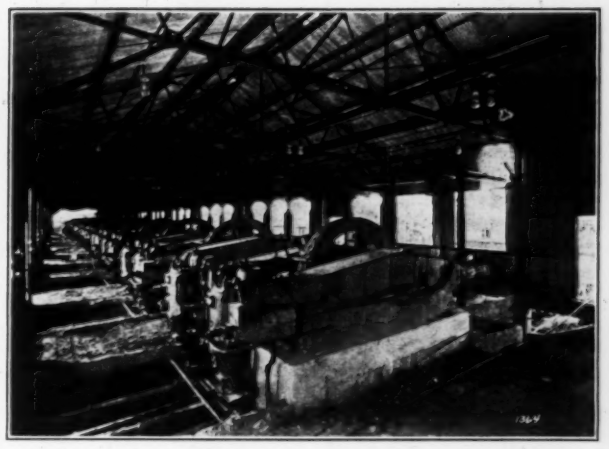
In cases where economic conditions have permitted, the use of electricity for power purposes has had considerable impetus, but it is not promised that that medium will be general as local conditions must be considered.

GAS INJECTION ON TWO-CYCLE ENGINES

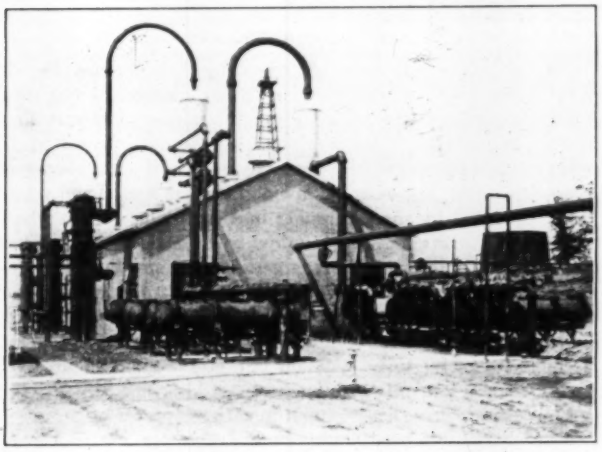
The gasoline industry is the first to apply the more recent development in internal-combustion engineering. This is the application of gas injection on two-cycle units, which makes them operate on the Diesel cycle rather than on the Otto cycle. Preliminary results point to economy on two-cycle units comparable with that expected in four-cycle operation.

The construction of large units has called forth great improvement in the design of cooling towers, which appear to have largely supplanted spray ponds. While atmospheric-type coils continue to be used for cooling and condensing service, the shell-and-tube-

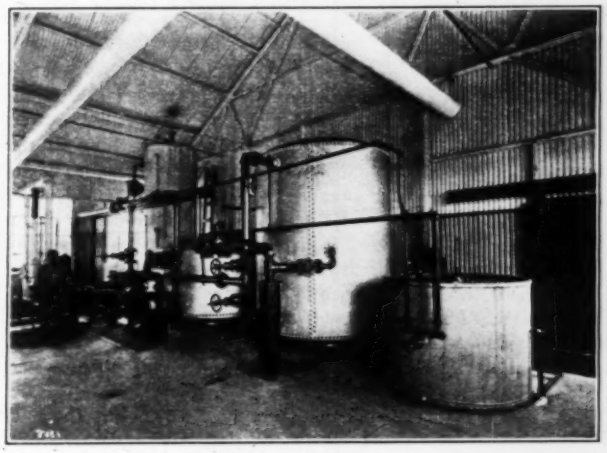
CONTROL BUILDING, NATURAL-GASOLINE PLANT



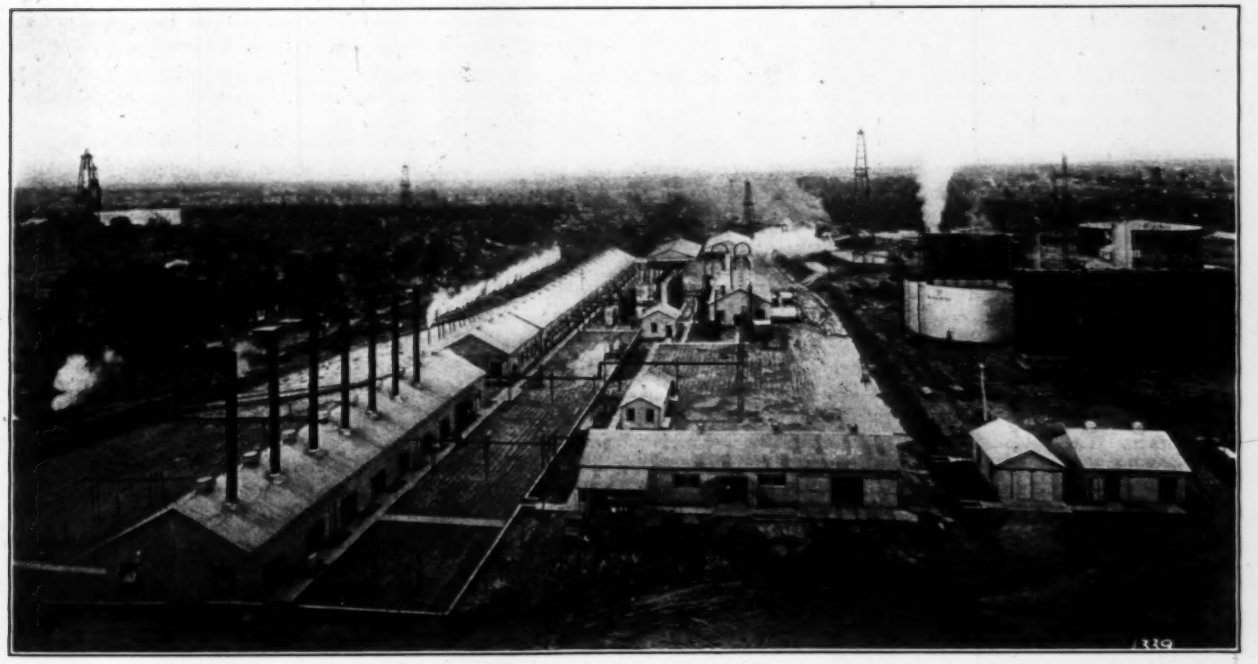
ENGINE ROOM OF NATURAL-GASOLINE PLANT CONTAINING THIRTY-TWO 180-HP. COMPRESSING UNITS



EXTERIOR VIEW OF CONTROL BUILDING ABOVE



ZEOLITE TREATING SYSTEM FOR HANDLING WATER OF HIGH TURBIDITY



GENERAL VIEW OF A NATURAL-GASOLINE PLANT IN THE SEMINOLE FIELD

type design is rapidly becoming preëminent. Certain advantages of the atmospheric coil and recent improvements in its design assure its continued use, and it is not expected that it will be entirely supplanted by shell-and-tube-type equipment when proper consideration is given to the local conditions surrounding individual installations.

It may be said in conclusion that the past year has been one of great progress in the gasoline industry, not only through the increased scale of its operations, but because of the greater attention given to detail of design and utilization of equipment. During the past year the three largest gasoline plants in the world were constructed, one in California and two in Seminole County, Oklahoma. The lowest natural-gasoline prices in history have demanded more efficient conception, design, and operation in all branches of the petroleum industry, and in the advance and application of engineering knowledge the natural-gasoline branch of that industry has had its due share.

Development of Transportation of Crude Oil in 1927

By B. P. SIBOLE

ON THE rails, in the water, on the highways, and through the air, "Speed" has been and is the slogan. In marked contrast to this, "Conservation" has been the keynote in the transportation of crude oil, especially by pipe line. This is particularly noteworthy, because an occasional suspicion of waste has been directed to this branch of the oil industry.

All crude oil is gathered from the wells by pipe lines, and while a small portion is carried to delivery or tidewater by tank cars, most of it goes on to such delivery by pipe line. Over two million barrels (or 300,000 tons) are handled every day by pipe line. Much of it is transported in this way for hundreds of miles, and yet all of this enormous movement is carried on safely and with a very high degree of economy.

Pipe lines have been extended into new fields, but the outstanding tendency in 1927 has been the development of still further economy and measures of conservation both on new lines and on old lines already in operation. This development has been marked by conservation of oil and equipment, and economy of movement.

Conservation of Oil

Long ago the pipe lines developed ways and means which have practically eliminated loss by leaks and breaks. In recent years the losses due to the fugitive vapors escaping have been the subject of constant attack. The floating roof continues to achieve excellent results in eliminating vapor loss from working tanks, and this year witnesses the appearance of the breather roof, which is an ordinary steel roof welded to the shell and so designed that it will rise and fall (as a diaphragm does under varying pressures) to take care of an ordinary change in volume of a tank practically full of crude oil without the safety relief valves being called on to operate. This type is for storage tanks.

The expensive lessons taught when lightning ignited large concrete storage reservoirs in California last year have resulted in the development of spires and aerials for the protection of such storage. The splendid record of comparative immunity from fire held by properly vented steel-roof storage tanks has resulted in a continuation of the tendency to build this sort of tank and replace wood roofs with steel.

Conservation of Equipment

No radical change or improvement in materials has been made. All of these continue to suffer from the ravages of corrosion. The enormous depreciation of pipe in the ground has continued to stimulate the development of protective coating for steel pipe, which material is still the almost universal standard for pipe lines. It was just two years ago that a type of pipe-cleaning machine was brought out which has in the last year been put into very wide use. By a device of this kind, old lines can, after they are uncovered and raised, be quite effectively cleaned, permitting the outside pipe surface to receive a coating of asphalt, tar, or other protective materials. Recently such a machine has been used on new pipe as received from the mills, with the apparent object of removing the mill scale and getting a fairly clean and new metallic surface to which to apply protective coating.

While heretofore most of the corrosion of pipe-line equipment has been on surfaces not in contact with crude oil, such as the outside of pipe lines, the outside of tanks, and the inside of steel roofs on tanks, there is promise of a still more serious problem in the handling of oil from West Texas and the Texas Panhandle, as much of this oil carries with it hydrogen sulphide or its compounds.

Economy in Movement

While reciprocating pumps driven by oil engines handle most of the oil, especially in the Mid-Continent Field, this year has been marked by the adoption of a number of electrically-driven installations. Motor-driven stations have resulted in saving of man power and investment as compared with oil-engine-driven stations. For example, a small electric motor and pump can be operated by the field gager in a gathering system where an additional man might be required with an oil engine. Electrically driven pumps both for large field stations and main-line stations have been installed with economy in time, investment, and, in some cases, in man power. This electric motive power is especially attractive in handling flush oil from new fields where the quantity of oil to be handled is pretty certain to drop off rapidly after a few months.

While electric drive has been put in with reciprocating pumps—the type heretofore used almost exclusively—the use of electric motors has made practicable the adoption of centrifugal pumps for oil-pumping service. This development is something of an innovation in the Mid-Continent Field where centrifugal pumps for pipe-line stations have not been used as they have in California. The direct-connected motor and centrifugal pump has found an economic use in temporarily increasing the capacity of an ordinary pipe line of 40 or 50 miles between the established main-line stations.

Oil engines continue to replace steam equipment at some of the pipe-line stations where steam was originally installed.

Venturi meters as well as liquid meters of other types are being tried out and considered more seriously for the measurement of oil.

There is a continued tendency to replace boilers and steam pumps for more or less temporary field use, with oil- or gasoline-driven portable units.

As in many other branches of the oil industry, welding continues to be more widely used in transportation. Some pipe-line companies are almost standardizing on welded lines; others are using it more widely than ever for river crossings, manifolds, and repairs.

While conservation has been the keynote, the industry has not lacked the extension of pipe lines into new fields. Three trunk pipe lines have been built into the Texas Panhandle and two into the new West Texas fields. These new extensions in the Mid-Continent Field cover considerable mileage of pipe and are built along the same general design considered as good practice in the last few years, having steel pipe operated at about 700

lb. working pressure with stations comprising oil-engine-driven reciprocating pumps. Another line now under construction is designed with electric-motor drive.

While part of the transportation of crude oil from isolated or temporarily congested districts is handled by tank cars on the railroad, the pipe lines continue to be the principal and most economical way to transport crude oil.

The refineries located on the Eastern Seaboard will of course continue to receive the greater portion of their crude-oil supply by tanker. A number of these have been acquired during the past year, either as re-engined Shipping Board vessels or newly constructed ships. Most of these ships are provided with either direct Diesel-engine drives or Diesel-electric drives.

Progress in Refining

By WALTER SAMANS

THE petroleum refining industry governs the progress in its methods from year to year by the existing conditions, which are ever varying. There is therefore no definite program which can be adhered to for long periods of time, and what may be good practice in one year may be superseded for very good reasons in the next year or thereafter.

The governing factor in progress is supply and demand, the same as it would be for any manufactured article. The influence of the past year's production of crude oils at approximately 20 per cent above the normal, and the uncertainty as to how long this excess production will continue, are bound to affect the viewpoint of the refiner as to the process value of existing and new equipment and the result on sale prices. Under such conditions the equipment available is put to the best possible use, and as in the case of some cracking stills at the present time, it may only be used because it is available and because of the need for disposal of cracking stock, even though the difference in market value between the raw and finished product from this type of still be insufficient to warrant cracking. The natural result of an excess in crude production is lower market prices, as storage of raw products involves considerable expense; and as lower prices of finished products also result, the profits in the business must be the real guide to the refiner in planning new investments.

In considering the progress which has been made during the last year or more, it might be well to divide the subject into five sub-headings as follows:

1 The savings in manufacture which may be obtained
2 The construction and engineering problems
3 The various processes in vogue
4 The developments in the manufacture and use of steam and power, and
5 The research work being done for future development.

Savings Possible in Manufacture

1 As the profits of a business decline, no matter for what reason, possible savings must be obtained in every branch of manufacture, and this is no less true of the refining industry than in the production of raw materials or in the marketing of the finished products. It is not only necessary to avoid waste wherever possible, but also to increase the yield of the more valuable products.

The crude oil when received at a refinery is stored in tanks of the larger sizes. To cut down evaporation losses, tanks are provided with gas-tight roofs and with vents which restrict the escape of gas and the intake of air as the volume of the oil in the tank changes due to pumping in or to outage, and to temperature changes. The latter action is commonly known as "breathing," and takes place principally between day and night conditions. In addition, these breather vents are provided with a flame arrester, so that in case of fire nearby, or if a tank be struck by lightning and the steel is not ruptured, the flame will not be communicated to the contents of the tank. Sometimes a pressure as high as 1 lb. per sq. in. is maintained on this gas space by these control vents, in which case the roof is built in the shape of a segment of a sphere, commonly known as a dome roof and also termed an umbrella roof. In other cases breather bags, made of balloon material and housed from the weather, are connected with the vapor spaces in one or more tanks so that the breathing may take place in a closed system and gas cannot therefore escape to the air. A similar system, involving the use of a gas holder connecting to a number of tanks in a group, has been used, but the size of the lines required on account of the large volume and low pressure of the gases involved makes the initial cost very high. The principal loss in evaporation—and this applies to finished light material such as gasoline even to a greater extent than to crude—is the absorption of gasoline vapors by the air in contact with the liquid. This quantity varies from 10 to 15 gal. of gasoline for 1000 cu. ft., and as this is a high-priced product, the loss is quite important. Another method used for the conservation of such materials is the installation of floating roofs, which in effect are metal pans properly braced and provided with flexible contact shoes between the shell and the tank. A second type of floating roof consists of a series of pontoons with flexible connections at the joints and also provided with flexible contact shoes against the tank shell. These roofs float on the liquid, the idea being to do away with evaporation by eliminating the air space over the liquid. With lighter distillates under a pan type of floating roof the heat of the sun tends to boil off the lighter fractions in contact with the under side of the roof, the gases escaping at the edge of the pan. To minimize this, the roof may be insulated. Insulation may also be applied on top of the steel roofs of gas-tight tanks where the nature of the contents makes it desirable, and this will restrict the fluctuation in temperature changes, and therefore the breathing losses.

One of the largest savings that has been obtained is in the fuel used under stills, this latter forming approximately 40 per cent of the manufacturing expense. The old type of still, consisting of a horizontal steel shell set on brick or concrete masonry, with more or less structural steel, had an efficiency of from 20 to 30 per cent. The latest types of stills, whether the heating elements consist entirely of tubes or are partly shells, have an efficiency of 60 to 75 per cent. The gains are accomplished by the use of better-constructed furnaces, provided with instruments for better-regulated control of fuel and air, and take advantage of the radiant heat and convection heat in the best possible manner, which minimizes stack losses. The low rate of heat transmission from the flame to the oil inside of a still of the old type—6000 B.t.u. per sq. ft.—has been improved by the increase in velocity of the oil being heated through a pipe coil, and also by the addition of extended surface on the outside of tubes to a maximum of 25,000 B.t.u. per sq. ft., and data are in the hands of manufacturers to enable them to predict fairly accurately the results to be obtained from any given design.

Various types of stokers have been in use for some time on stills of both the old shell type and the later continuous types using forced circulation. Within the last year powdered coal has been applied to the latest type of tube stills with apparent success, resulting in efficiencies equivalent to good refinery boiler practice.

The efficient use of heat is naturally being supplemented by the proper use of insulating materials. This not only provides for layers of insulating brick, or outside insulation of settings, but

also for the covering of all piping and apparatus where radiation is undesirable.

One of the largest of fuel savings in connection with oil distillation has been obtained by the installation of tubular heat exchangers. The early days of such equipment were full of trouble for both the manufacturer and the refiner, due to the inadequate knowledge of this subject compared to steam practice, or that in other industries in which the materials were not handled at high temperatures or did not interfere seriously with heat transfer, and where corrosion was not a serious problem. For the heavier by-products of refining the heat transfer is as low as 10 B.t.u. per sq. ft. per degree of temperature difference, while for the lightest products the value may reach 70 or 80. This matter is further complicated by the limited pressure drops available as required by the process of distillation and the need for space between tubes for cleaning.

The natural low efficiency of heat transfer where oil is on one side of the tube surface and water is used for cooling makes it essential that clean water be used, and some of the refineries are putting in auxiliary coolers in which river water, which may contain a variable percentage of mud and slime, is used to cool deaereated water which operates as a cooling medium for the oil in a closed system. This cuts down the cleaning time and therefore the shutdown periods on the more expensive oil-distilling apparatus.

Naturally the introduction of instruments, both for control of fuel conditions and the specifications of the products, requires a higher class of labor, and to keep down the expense of this part of process, which in total averages 20 per cent of the refinery's manufacturing expense, the stills are built in batteries, and each unit is as large as practicable.

Construction and Engineering Problems

2 From the construction and engineering standpoint, studies are constantly being made of the possibilities of various materials, of which a great number are on the market, and particularly is this necessary from the standpoint of corrosion. Every crude oil contains sulphur in some form, even though it be a very small percentage in some of the better crudes. Chlorides may also be present in some crudes, which results in the formation of hydrochloric acid, and this must be provided against. Any alkali added in some portion of the refining process may affect certain construction materials which would otherwise be most useful. The various alloys, both ferrous and non-ferrous, are continually studied and tested, and at the high temperatures and pressures prevalent, particularly in cracking, the physical properties of the materials used must also be considered. There must be no uncertainty in the metallurgy of a finished metal that is used in any part of the apparatus, as naturally in a large, expensive unit an enforced shutdown is very expensive.

High-pressure cracking processes have developed the manufacture of forge-welded chambers for this work. These are made in various diameters and over 40 ft. long, with thicknesses varying according to requirements up to $5^1/_2$ or 6 in. The ends are necked down and provided with flanges and covers, and a finished chamber of 52 in. inside diameter and 42 ft. long will weigh from 50 to 70 tons, depending upon the amount of machining that is done, whereas the original ingot from which the forging is made may weigh as much as 200 to 250 tons. These single forgings are being made both in this country and abroad.

Another development within the last few years on such large chambers is an electric-fused welding process in which the welding material is such that air is prevented from acting upon the material being welded. The chambers are made up of plates of the thickness required for considerable length with relation to width, and curved in the width to suit the radius of chamber desired. Chambers of this type have been in use in the Holmes-Manley and other processes and are giving satisfactory results.

Present-day refinery operators must keep pace not only with the market demand but also provide for available space for incoming shipments of crude oil, and this is governed by the kind of equipment and the capacity of tanks available. Every operation is scheduled, and the complications added by the use of pipe or tube heating coils, heat exchangers, condensers, and coolers necessitate that the cleaning of this apparatus be done in the most efficient manner. At the same time repairs must be carefully watched, and this is accomplished by a regular system of inspection, providing not only for the safety of the operators but also for the replacement of worn-out equipment when necessary. All such information is carefully recorded and studies are made for the improvement of conditions.

Protection of every kind must be provided, not only for the operators, for which no expense is spared, but also for the equipment. In consequence construction is now built for permanence and fire resistance, and every enclosed or semi-enclosed space must be properly ventilated. While the ground space occupied by equipment as now constructed may only be 25 per cent of that occupied by equipment of the same capacity some years ago, the structure has reared itself in the air, due to the natural requirements of the process; and whereas the old-type structures, with the exception of stacks, seldom exceeded a height of 25 ft., the apparatus may now extend upward 70 to 90 ft.

The protection of operators and the apparatus as a whole must be supplemented by protection from corrosion, which may occur in the materials used, particularly alloys as above noted, or also in the special coatings provided. Surface applications of metal to metal, or inert compounds applied to surfaces exposed to hot oil and vapors, are used, and in some types of stills such surface protection not only provides against corrosion but also against the adherence of carbon deposits. This is very essential in maintaining an efficient heat transfer on heating elements, for as soon as this stops or is hindered seriously the heating elements will increase in temperature until they are no longer able to carry the load, and the apparatus must be shut down.

With temperatures ranging from 800 to 1000 deg. fahr. and pressures varying from 0.5 in. or less of mercury to 1200 lb. per sq. in., it is natural to conclude that the problems of the oil refiner will never be entirely solved.

The Various Processes in Vogue

3 The processes selected by the refiner for obtaining marketable products from the crude are naturally dictated by supply and demand, and by the economies obtainable. The quality of the product is of first importance, as nowadays the competition and the purchaser's knowledge of his requirements make it impossible to maintain sales except by strict adherence to specifications. Crude oil being a mixture of a number of combinations of carbon and hydrogen having different boiling points, may naturally be separated by distillation. Every one of these compounds, however, may be broken up into other compounds by overheating during this process, and there is a fairly definite range of pressures and temperatures under which these conditions will occur.

Before the advent of internal-combustion engines, particularly gasoline engines, there was no great proportional demand for naphthas, or what we now term motor gasoline. Cracking for a purpose was unknown, and all crude oil was distilled in batches and fractionated by gradually increasing the temperature of the oil and in an approximate way boiling off each product in turn. Impossible uniformity of heat distribution, due to the crudeness of the apparatus, resulted in overlapping of the various fractions, and the distilled products so obtained had to be rerun,

that is, again passed through the evaporating and condensing process. Each run resulted in losses that were unavoidable. The application of continuous distillation, and later the use of fractionating columns, has resulted in the modern pipe still, which produces continuously various fractions from the crude oil to desired specifications with rerunning reduced to a minimum and without scarcely any further processing except treating, and consequently with greater percentages of recovery of various products.

The heavier the products the more apt they are to crack. That is, the lubricating oils will be affected in this way at lower temperatures and pressures than kerosene and naphthas. This has resulted in the development of the vacuum distillation process, which lowers the boiling point of the liquids and at the same time gives greater yields which are claimed to be of better quality. With present knowledge in the foundry and machine shop, it is possible to produce apparatus in which a very high vacuum can be maintained and which will operate efficiently for long periods of time. The use of multi-stage thermo-compressors makes it possible to recover the steam and further improve the overall efficiency of the apparatus.

While the fractional distillations above mentioned are carried on at a pressure close to atmosphere or in partial vacuum, the development of the gasoline engine has in past years made it necessary to greatly increase the yield of the lighter fractions in proportion to the crude oil available and to the other products desired. This naturally resulted in the development of cracking processes which require fairly definite temperatures, and the maintenance of high corresponding pressures, if the cracking is to take place in apparatus of reasonable size and without evaporation. This involves high-pressure pumps for charging those fractions of the crude of which a surplus existed, mainly gas oil, and the use of digesting or reaction chambers in which the process can be completed after the oil has been heated to the proper temperature. While very little is known of what actually takes place, it was indicated that the time element was of some importance, and that the action of cracking was not instantaneous. Following this phase of the operation the pressure is released, and the mixture of gasoline obtained, together with some carbon and fixed gas, and the unaffected portion of the charge are expanded into an evaporating chamber and from there carried into a fractionating tower. This consists of a vertical shell equipped with a number of trays arranged in tiers, these trays having openings covered with caps. On each tray a certain amount of liquid collects, through which the steam and vapors have to pass, distribution of vapor through the liquid being accomplished by serrated edges on the bottom of the caps. This apparatus is commonly know as a bubble tower, and as the temperature drops from the bottom of the tower upward, the light distillates are separated from the lower-boiling compounds, so that at the top of the tower steam and practically pure gasoline vapor are taken off and led to the condensing apparatus. In such a tower used with fractionating pipe stills, other products are removed at intermediate trays; and the heaviest fraction, commonly termed "bottoms," is reduced to the lowest possible percentage. During the past few years it has been found that crude oil can be charged direct into cracking apparatus, and the natural naphtha and the cracked naphtha can thereby be removed in one operation with possibly less loss than by carrying out the fractionation of the natural naphtha separately from the cracking apparatus.

It can readily be seen that as crudes vary in their natural components and the demands of the market also vary for various finished products, the refiner has a constantly changing problem, demanding the best and most economical method of refining. During the last year the number of fractionating stills—commonly known as pipe stills due to the type of heating element—and the number of cracking stills have been greatly increased, although the excess production of crude has reduced the number of cracking stills that might have been built.

The vapor-phase type of cracking stills and the aluminum-chloride process of cracking are also in successful use, but have not had the same growth in number as the liquid-phase type of cracking stills. Vapor-phase cracking may have a special use in producing gasoline with fewer detonating characteristics.

All products as they are obtained from the first distillation of crude oil must be treated in some way. Sulphuric acid is still being used for decolorizing, but there has been considerable development in the application of clay filtration. The old method by percolating filters is being superseded on some oils by fine-clay contact treatment. The principle of this process depends upon mixing this material with the oils at proper temperatures in stirring agitators and then allowing it to settle, the number of stages of mixing and settling depending upon the refinement desired. A light acid treatment usually precedes the clay treatment.

The reconditioning of spent clay from the filtration processes has been successively accomplished by means of rotary kilns and gravity-flow driers, and in the latest plants the Herreschoff and Wedge furnaces are used, resulting in longer life for the clay.

The Edelanea process of refining, involving the extraction with liquid sulphur dioxide, is gaining headway on the Pacific Coast, and its wider use may be expected.

The use of the centrifugal method of dewaxing has become more general, and its application has been broadened.

It has been found that gasoline vapor can be treated by passing it through a fullers' earth filter, and this is superior to sulphuric-acid treatment of liquid gasoline, as the latter tends to destroy some of the anti-detonating compounds.

DEVELOPMENTS IN MANUFACTURE AND USE OF STEAM AND POWER

4 With reference to steam and power requirements, the older types of refineries had use for a large quantity of process steam, and it was natural that their boiler plants were built mainly for this purpose, generating steam at pressures from 80 to 250 lb. and obtaining electric power by means of turbines working on 10 to 15 lb. back pressure, or using the bleeder type of turbines suitable for variable steam conditions.

The process steam required for distillation in the new type of stills is about one-third less per barrel of oil distilled than formerly, and at the same time, on account of the higher pressure required for charging pumps on crude stills and the extremely high-pressure charging pumps used on cracking stills, electric power applied through gear drives is coming rapidly into use, and more generating capacity is thereby required.

The development of high-pressure boilers and higher pressure in distribution mains for steam over widely extended plants, and the resulting improved economy, has benefited large refineries in the same way it has other industries. It has even been found desirable in some plants to generate power by means of oil engines. In the use of cracking processes the quantity of gas produced has increased, and naturally the installation of stripping plants by means of which gasoline vapors are removed from the still gas before it is burned, has made gas-engine drives possible for air and gas compressors and similar service, particularly at points far removed from a supply of steam or electricity.

The modern cracking still may require a hot-oil pump with a forged-steel liquid end handling about 180 gal. of oil per min. and operating at 650 deg. fahr., and 1200 to 1600 lb. pressure, and such pumps may be steam driven with compound steam ends, or motor driven, in which case variable-speed motors are preferable. Where steam is available in suitable pressures and

quantities, a steam pump is preferred, but as the power pumps have been found to operate very smoothly under such conditions and with some improvement in economy, they may in the end be found more suitable.

5 Regardless of where crude oil is obtained and in what quantities it may be obtained compared to the demands for finished products, the necessity of making profits against severe competition calls imperatively for continued research work toward improvement.

RESEARCH WORK UNDER WAY

The Bergius process for obtaining products similar to those obtained from petroleum by distillation of coal under 200 atmospheres has found favor abroad, due to the peculiar situation there with reference to the crude market, and in the past year the rights on this process for this country have been obtained by the Standard Oil Company of New Jersey, although it is not expected that the process will become commercially feasible for some years to come.

In the application of radiant heat, several stills are under construction in which the oil heater tubes form the inner enclosure of the combustion chamber.

Research work is being done toward the recovery of a greater portion of the by-product gas from petroleum distillation than is now obtained by stripping processes, for use in motor fuels.

While the number of small plants obtaining petroleum products from shale oil is increasing, the proportion of these products, compared to the total market requirements, is very small.

Summarizing the entire field of refining, the last few years have indicated remarkable strides toward improvement, and the application of the latest methods in process, construction materials, and the actual use of apparatus in operation has become a highly technical subject.

Progress in Aeronautics

Contributed by the Aeronautics Division

Executive Committee: Edwin E. Aldrin, *Chairman*, Alexander Klemin, *Secretary*, William Knight, Archibald Black, Elmer A. Sperry, and William F. Durand

THE year has been marked by rapid growth in every phase of aviation activity. The remarkable flights of Lindbergh, Chamberlin, and Byrd were a testimonial to the reliability of the modern air-cooled engine, and to the value of such navigating instruments as the earth-inductor compass. They did not demonstrate the immediate possibility of regular transatlantic services. Rather the general impression remains that an immense amount of work is still to be done: in securing an adequate weather service for ocean pilots, far more complete that the spasmodic reports now received from surface craft; in constructing very large multi-engined seaplanes, capable of continuing flights with one or two engines out of commission and quite seaworthy after alighting; and in the improvement of methods of aerial navigation. But the flights did have the effect of focusing the attention of the entire country on aviation. The tremendous popular interest they aroused has had a most gratifying effect in stimulating air-transport operations, in the construction of a large number of airports (with the exception of New York, practically every city of importance has already established an airport), in increasing the sale of commercial craft of every description, and in the increase of flying instruction, air-taxi work, and every other form of aerial-service activity; and while technical developments have been steady and successful in many phases of the art, it is the remarkable developments of commercial aviation that is the outstanding phenomenon of the year.

POWER PLANT[1]

An interesting feature of the year has been the predominance of the air-cooled type of engine; only two water-cooled engines worthy of note have been brought out during the past twelve months, namely, a twelve-cylinder V-engine built by the Curtiss Aeroplane & Motor Company, and a twenty-four-cylinder X-engine built by the Packard Motor Car Company.

The Curtiss engine has a displacement of approximately 1550 cu. in. and is built both in direct and geared models. The weight of the geared model (Gv-1550) is approximately 840 lb. and that of the direct drive (V-1550) is 755 lb. With normal compression ratio the engine develops 600 hp. at 2400 r.p.m. By resorting to high compression and slightly increased r.p.m. the direct-drive engine can develop sufficient power to bring its weight rating to practically one pound per horsepower. This is a distinct advance for American engines, though it is believed that the racing Napier Lion and Fiat engines come well within the pound-per-horsepower class.

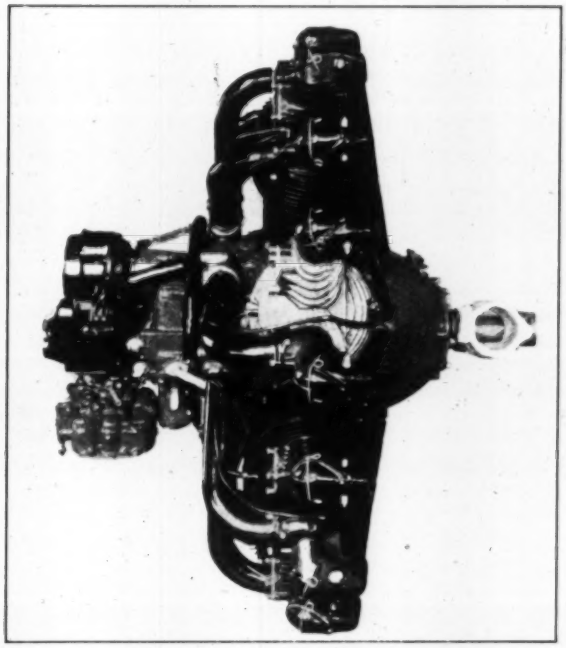
The Packard twenty-four-cylinder X-engine is virtually two Packard 1500 engines, one upright and the other inverted, assembled to a common crankcase, having a displacement of 2775 cu. in. and developing approximately 1300 hp. and weighing about 1475 lb. It is built for the Navy and passed its acceptance tests in a very satisfactory manner. It is an exceptionally light and compact engine for its power rating.

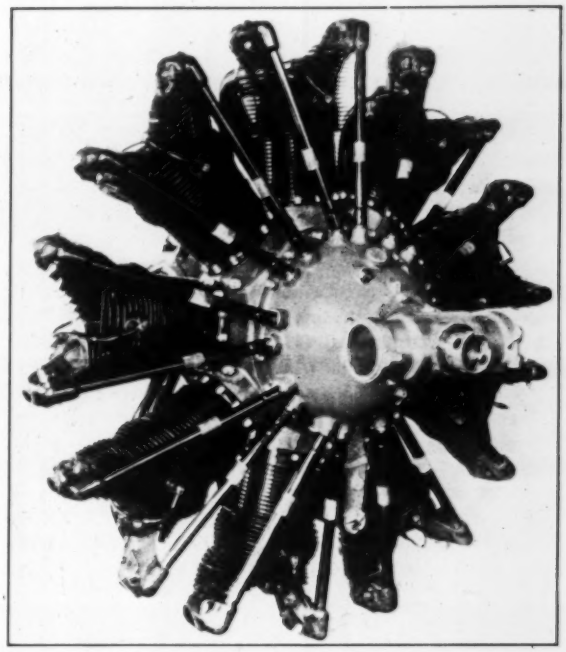
The Wright Whirlwind, a nine-cylinder air-cooled radial engine —the result of seven years' development—rated at 225 hp. at 2000 r.p.m., has been adopted as the standard training engine for both the Navy and the Army, and has contributed in no small amount to the success of such feasts as Lindbergh's New York-to-Paris Flight, Byrd's Transatlantic Flight, the San Francisco and Hawaii Flights, and Schlee and Brock's attempted flight around the world.

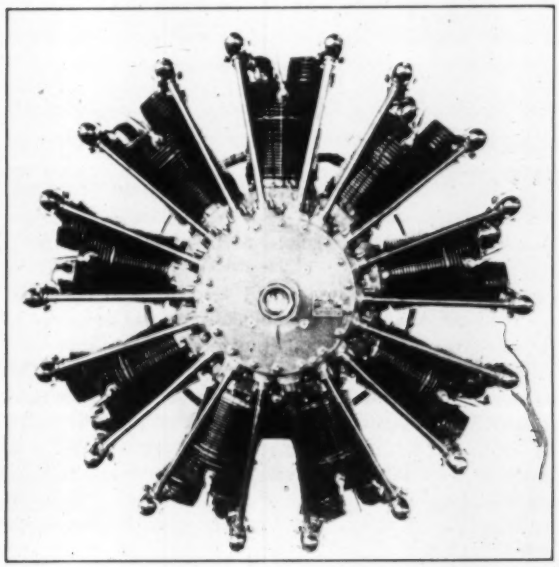
The Pratt & Whitney Wasp engine brought out last year is a nine-cylinder radial engine rated at 425 hp. at 1900 r.p.m., at normal compression ratio, weighing approximately 650 lb. without accessories. It has been adopted as standard by the Navy for their single-seater fighters and for their two-seater observation planes for shipboard use.

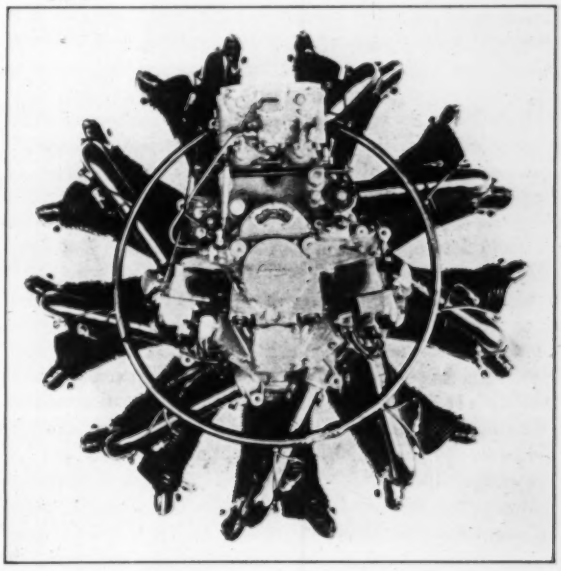
Both of these types of airplanes equipped with the Wasp have an all-around performance at least equal to, if not better than, that of the same types equipped with a water-cooled engine of comparable horsepower. The excellent cooling qualities of the Wasp cylinder are amply demonstrated by its performance under supercharged conditions. Lt. C. C. Champion of the Navy

[1] Prepared by Capt. T. E. Tillinghast, Chief, Power Plant Branch, Army Air Corps., Wright Field, Dayton, O.

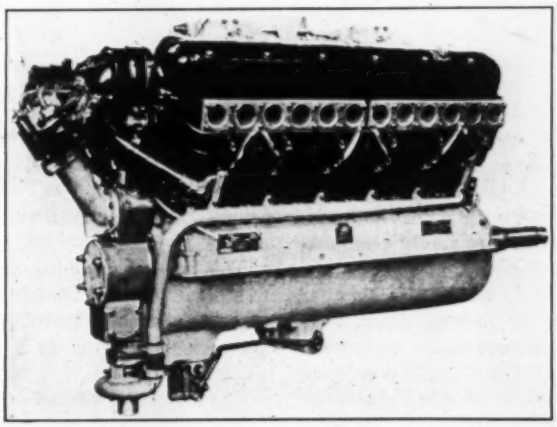








Above: Two Views of Pratt & Whitney "Hornet" Engine



Curtiss Model V-1550 Engine

Below: Front and Rear Views of Wright Model R-1750 Engine

flying the Wright Apache, equipped as a seaplane and powered with a supercharged Wasp, attained an officially recognized altitude of 37,995 ft., a new altitude record for seaplanes.

In conjunction with the Navy the Pratt & Whitney Company have designed and built a larger nine-cylinder radial of approximately 1700 cu. in. displacement, known as the Hornet, of which the Wasp was the prototype. This engine weighs about 750 lb. without starter and generator, and is rated conservatively at 525 hp. at 1900 r.p.m. It has passed all of its preliminary ground and air tests with great success, and the Navy has placed a substantial production order for the engines for a single-engine torpedoplane.

The Wright Aeronautical Corporation have also developed for the Navy a nine-cylinder radial air-cooled engine of approximately 1750 cu. in. displacement, known as the Wright Cyclone. This engine is rated conservatively at 525 hp. at 1900 r.p.m. and weighs approximately 795 lb. It has made an excellent showing on its preliminary tests.

As a result of the promising results obtained with the air-cooled Liberty engine built for the Air Corps by the Allison Engineering Company, Indianapolis, Ind., the Wright Aeronautical Corporation have been encouraged by the Army to design a V air-cooled engine. The first engine of this type is now practically completed and is expected to go on test shortly. It is an inverted V-engine having a displacement of approximately 1456 cu. in., and designated as the V-1460. It is smaller than the air-cooled Liberty in overall dimensions and is estimated to develop 600 hp. at 2500 r.p.m., and to weigh 900 lb.

The Curtiss Aeroplane & Motor Company are developing a very interesting air-cooled engine for the Air Corps, known as the Hex-1640. It is a double-row radial engine having twelve cylinders, with the cylinders in tandem instead of the conventional staggered arrangement. It has a displacement of approximately 1640 cu. in. and employs the air-cooled V method of cooling the cylinders. The first engine, weighing 900 lb. and developing 600 hp. at 2250 r.p.m., is now undergoing development tests.

It will be seen in comparing the weights of the 525-hp. radial engines with those of the V and Hex types, that the radials are much lighter per cubic inch of displacement and slightly lighter in weight per horsepower. There is, however, an excellent possibility of obtaining a greater displacement per minute in the V and Hex types by resorting to higher crankshaft speeds than would be safe in the radial, thereby obtaining weights per horsepower comparable to those of the radial types. It is also thought that due to the smaller frontal area the Hex and V types may have less resistance than the radial, and better fighting visibility.

For the past few years the war surplus of Curtiss OX engines has been fast diminishing, and the need for some replacement for commercial service has encouraged many engineers to produce air-cooled engines in this size. Brief mention of some of these engines follows.

The Cam engine, built by the Fairchild Caminez Engine Corporation, has recently passed a very successful 50-hour test, developing 100 hp., and is being placed in regular commercial operation. It is a 4-cylinder engine with pistons acting directly on a cam, dispensing with the conventional crank and connecting rods. This results in each of the four cylinders completing its four-stroke cycle for one revolution of the crankshaft. The engine weighs approximately 340 lb.

The Aeronautical Industries, Inc., of Detroit, Mich. have recently designed and built a small seven-cylinder radial air-cooled engine weighing approximately 275 lb. and developing 110 hp. The engine has passed a very creditable 50-hour test at 110 hp. at 1800 r.p.m., and is undergoing flight tests at present.

The Klamath Air Service Company, of Klamath Falls, Ore., are building the Bailey Bull's Eye engine, a seven-cylinder, L-head, air-cooled radial developing 140 hp. at 1850 r.p.m. and weighing 325 lb.

The Kinney Manufacturing Company, of Boston, Mass., are building the Kinney-Noble five-cylinder air-cooled radial which develops 75 hp. at 1800 r.p.m. and weighs 147 lb. An interesting feature of this design is its hydraulic valve gear.

It is particularly gratifying to note that the many new engines built have been forced to undergo no laborious periods of testing and changes. Almost from their first layout on the board, their design, while not lacking in originality and improvements, has been consistent with good engineering practice, and the first model has acquitted itself remarkably well on test. This marks a new era in the art of aeronautical-engine design.

AIRPLANE DESIGN AND CONSTRUCTION

The airplane has for the time being reached a stage where progress is a matter of gradual evolution. American designers are constantly improving the structure and aerodynamics of their craft, but it is only in what might be called the subsidiary parts of the airplane that decided novelties may be noted. Some of these are: independent wheel brakes; hydraulic wheel brakes, as employed by the Curtiss Aeroplane & Motor Corporation; general use of oleo gear in application to the landing gear, and sometimes to the tail skid; differential aileron control; balanced ailerons of the "Bristol Frise" type; adjustable seats with automatically compensating pedals; single-dual control for large two-pilot machines, duralumin tanks, nickel-plated and soldered. In the Loening Amphibians the adjustable stabilizer has been replaced by a "Bungee" system in which a spring adjustment on the elevator compensates for tail or nose heaviness.

A number of new amphibian planes have been produced by constructors such as Sikorsky and Ireland, and this type of craft is now generally recognized as being of real commercial utility.

Metal construction is now largely recognized as likely to replace wood construction completely. American designers such as Charles Ward Hall, W. B. Stout, and others have carried metal construction to a high degree of excellence and to remarkable values of strength-weight ratio. Designers are now turning their attention to ease of production by the substitution of open tubes for closed tubes, the use of pressed sections and similar methods both for wing, spars, ribs, and pontoon and hull parts. Much attention has also successfully been given to the easy production of corrugated-metal covering and to riveting processes.

In commercial airplanes a great many new firms are engaging in the construction of small three-seater planes for aerial service work. These planes when equipped with the OX-5 engine are sold at prices around $2250, and are entering on a real production phase. Some factories are said to be producing and selling three planes a day of this type, which is a condition unprecedented in the airplane industry either here or abroad. A larger and more expensive commercial type is that of the five-seater, enclosed-cabin monoplane such as the Ryan, Fairchild, Bellanca, Stinson, etc., equipped with the Wright Whirlwind engine and selling at about $11,500.

This type of plane has almost been standardized in the form of a braced monoplane, with pilot as well as passengers enclosed and with considerable attention given to interior finish and passenger accommodation. It is also being used for carrying mail on the feeder air lines.

So many small commercial planes are now on the market that a statistical summary is impossible. The two following planes

may, however, be taken as fairly representative of their types.

Advance Aircraft, "Waco" biplane; pilot and two passengers; Curtiss OX-5 engine, 90 hp. at 1400 r.p.m.; overall length, 23 ft. 5 in.; overall height, 9 ft. 3 in.; span, 31 ft. 7 in.; chord, 62½ in.; area, 283.6 sq. ft.; weight empty, 1148.5 lb.; gas and oil, 254 lb.; useful load, 800 lb.; gross weight, 1948.5 lb.; high speed, 100 m.p.h.; landing speed, 36 m.p.h.; cruising speed, 85 m.p.h.; cruising range, 3.7 hr.; climb to 1000 ft., 1 min. 48 sec.; useful load in per cent of gross weight, 41.67; weight per hp., 21.64 lb.; weight per sq. ft., 6.87 lb.

Fairchild FC-2 monoplane; pilot and four passengers; Wright Whirlwind engine, 200 hp. at 1800 r.p.m.; overall length, 30 ft. 11 in.; overall height, 9 ft.; span, 44 ft.; chord, 7 ft.; area, 290 sq. ft.; weight empty, 775 lb.; gas and oil, 560 lb.; useful load, 1425 lb.; gross weight, 3200 lb.; high speed, 120 m.p.h.; landing speed, 47.5 m.p.h.; cruising range 4.75 hr.; climb to 10,000 ft., 25 min.; useful load in per cent of gross weight, 44.53; weight per hp., 16 lb.; weight per sq. ft., 11 lb.

Particularly in Europe where passenger travel is much more common, the following problems in multi-engine design have been the subject of much discussion and some experimentation: namely, the heating and ventilating of passenger cabins, and the muffling of gas-engine exhausts and in general the decrease of noise. Preliminary reports in England indicate that a pusher-screw airplane can be made as efficient as one having a tractor screw. Such a design would be particularly interesting from the same point of view of noise elimination in the cabin. In the larger three-engine types the number designed and built has been small. Yet the multi-engined plane is considered by many constructors and operators an essential preliminary to the carrying of passengers. The Daniel Guggenheim Fund for the Promotion of Aeronautics has announced a plan whereby equipment loans will be made to a selected airline for the purchase of multi-engined passenger-carrying planes.

That airplane speed has not yet reached its final value is demonstrated by the results of the Schneider Trophy race. The race, held in Venice on September 26, was won by Lt. S. N. Webster of the British Royal Air Force, flying the supermarine Napier S 5. The average speed over a course of 217.483 miles was 281.488 m.p.h. The S 5, a twin-float, low-wing monoplane, is powered with a twelve-cylinder Napier Lion engine with three banks of four cylinders each. The seaplane exemplifies the last word in aerodynamic refinement, with the engine cowling fairing into the fuselage, tail surfaces fairing into the rear part of the fuselage, wing-surface radiators, and a type of windshield which offers a minimum of resistance. A Gloster-Napier biplane actually attained a speed of 289.75 m.p.h. over one lap of the course. A comparison of the high speed of the winners of the Schneider Trophy race for various years brings out the interesting fact that from 1921 the high speed has increased approximately 30 m.p.h. each year.

The only design of a radically novel character which has appeared during the year is that of the Focke-Wulf "Ente," in which the horizontal tail surfaces are placed ahead of the wing. Apparently longitudinal stability has been secured, and the design offers two great advantages: (1) As the tail surfaces reach their maximum lift first, the craft cannot be readily stalled; and (2) the danger of nosing over is eliminated.

AERODYNAMICS

In aerodynamics, progress is a matter of completely international character, and no developments can be regarded as belonging specifically to the United States.

Perhaps the outstanding event of aerodynamic importance during the past year has been the announcement of the Daniel Guggenheim Safe Aircraft competition for the improvement of the aerodynamic safety characteristics of heavier-than-air craft. The carefully framed rules of the competition call for a plane capable of slow landing, short landing run, short get-away run, steep climb, with ability to land in restricted territory by a slow, steep glide, stability in varied flight conditions, and the avoidance of all danger of spinning at the "stall." The competition is engaging the world-wide attention of designers and aerodynamicists, and is expected to forward the art considerably.

As a means of achieving slow landings without sacrifice of the high-speed characteristics of the plane, a variety of high-lift-producing devices are being studied. These include the Handley Page front slot in conjunction with a rear slotted flap, which has now been developed so as to be automatic in action, the application of suction to the upper surface of the wing to prevent breaking away of the air flow at high angles of incidence, and the ejection of compressed air for the same purpose. German periodicals report several important investigations on the latter two methods. The removal of the boundary layer by suction has also been investigated by British and American laboratories. There seems little doubt that this method can be made to improve the flow at high incidence with the expenditure of little power.

The National Advisory Committee for Aeronautics has given much attention to the elucidation of scale effects, correlating work in the compressed-air tunnel with full-flight tests.

The British have continued their studies of slot-and-flap ailerons and aileron control, and have definitely succeeded in securing lateral control effective at angles at or beyond the "stall." The British Air Ministry has fitted this control to airplanes of various services, apparently with little reduction of maximum speed.

American designers have given special attention to the use of constant-pressure wings with slightly-turned-up trailing edges, as a means of reducing structural weight and combining stability with good maneuverability. The results have not been as promising as was at first anticipated, because movement of the ailerons causes an appreciable displacement of the center of pressure.

Designers have also sought to combine the two wings of a biplane with different center-of-pressure motions to secure a constant center of pressure for the entire cellule.

Important British publications have appeared during the year dealing with the problem of spinning, which give promise of a complete understanding of its phenomena. At the National Physical Laboratory apparatus is being constructed which will allow the full representation of a spin in the wind tunnel.

Investigations on wing flutter appear in the reports of several American and European laboratories. It has been found possible to reproduce every type of wing flutter by the construction of special models in the wind tunnel. To eliminate flutter it appears desirable to design ailerons so that their center of gravity comes on the hinge and so that an appreciable part of their length comes inside the outer strut. A stiffer structure should also be of assistance in preventing flutter at anything but the highest speeds.

A valuable addition to photographic studies of air flow has been made by the Aeronautical Research Institute of Tokyo. A wheel about two feet in diameter is accurately ground with highly polished facets on its circumference. The image to be photographed is reflected by these polished surfaces to a cylinder on which the film is wound. By having the wheel and cylinder revolve in synchronism, with the cylinder at the same time moving along its axis, a new portion of film is continually presented for the reflected picture. In this manner 20,000 exposures per second have been obtained.

AIR TRANSPORT AND AERIAL SERVICE[2]

In the Progress Report for 1926 it was stated that the air-transport industry in this country was then passing through a period of probation.

Substantial results have now been accomplished in the building up of traffic. The volume of mail, packages, and passengers has been increased by the constant pressure of the various operators. One of the most substantial of the operators of scheduled routes is known to be making a comfortable profit, while several others are earning enough to cover actual costs. The outlook is excellent, and there is every reason to expect that many others will bring their accounts "out of the red" within the next year or so. Since the 1926 Report, however, some of the "weaker sisters" among the operating companies have been forced to suspend.

TABLE 2 STATISTICS ON SCHEDULED AIR-TRANSPORT ROUTES FOR SIX MONTHS ENDING JUNE 30, 1927

(Figures from U. S. Department of Commerce.)

		Miles flown, scheduled trips (*f*)	Passengers carried	Mail carried, lb.	Express carried, lb.	Air-mail income
	San Francisco-New York (*a*) (*b*) (*x*)	913,031	none	212,976	none	*g*
	Chicago-New York Overnight (*b*) (*x*)	233,417	none	88,048	none	*g*
M	New York-Boston (*x*)	53,020	231	8,164	100	$ 24,488.06
M	St. Louis-Chicago	63,987	2	16,999	21,651	43,024.77
M	Dallas-Chicago (*x*)	343,708	59	51,274	none	153,654.36
M	Los Angeles-Salt Lake City (*x*)	204,972	147	88,746	20	266,235.93
M	Salt Lake City-Pasco	147,340	none	22,612	none	67,838.63
M	Detroit-Cleveland (*d*)	78,144	none	826	646,599	894.30
M	Detroit-Chicago (*d*)	81,732	none	4,741	364,099	5,120.85
M	Los Angeles-Seattle	212,454	318	31,420	none	89,374.89
M	Chicago-Minneapolis-St. Paul	88,320	none	11,418	none	31,400.70
M	Cleveland-Pittsburgh (*e*)	16,959	4	4,674	none	14,020.87
M	Pueblo-Cheyenne	72,400	2	15,606	none	46,819.49
M	Pilottown-New Orleans	25,920	none	37,896	none	16,208.10
M	Seattle-Victoria	10,764	11	25,836	none	14,200.00
	Detroit-Grand Rapids	41,300	1,087	none	2,404	(*e*)
	Louisville-Cleveland	23,940	30	none	244	(*e*)
	Detroit-Buffalo	30,956	none	none	10,105	(*h*)
	Totals	2,642,364	1,891	621,236	1,045,222	$773,280.95
	Yearly rate on this basis	5,284,728	3,782	1,242,472	2,090,444	$1,546,562.00

Key:
- M Mail contract route.
- *a* Government-operated service (now privately operated).
- *b* Both day and night services operated (formerly Government, now contractor).
- *d* Private express and public mail.
- *e* Started only on April 21, 1927.
- *f* Obviously additional mileage was flown on uncompleted trips but it is not possible to account for this, hence the figures are low.
- *g* Government-operated during the period covered.
- *h* Private express route, no mail contract; started March 28, 1927.
- *x* Has American Railway Express Company contract.

TABLE 1 MILEAGE AND TRAFFIC STATISTICS FOR PRIVATELY OPERATED U. S. AIRMAIL ROUTES FOR YEAR ENDING JUNE 30, 1927

(Post Office Department figures.)

	Pounds of mail	Mail revenue[1]	Miles flown
July, 1926	28,158	$78,072	189,457
August	30,974	87,079	186,675
September	32,511	92,270	199,993
October	39,140	113,118	239,532
November	35,495	103,314	213,969
December	37,823	109,488	215,686
January, 1927	32,510	93,550	205,612
February	35,037	101,263	191,383
March	42,111	121,987	233,308
April	45,856	133,130	231,998
May	46,132	133,738	248,109
June	55,026	159,202	250,491
Totals	460,773	$1,326,211	2,606,213

[1] This figure represents the amount paid to the contractor, not the sum received by the Post Office.

Air-mail traffic has undergone constant development, the extent of which will be better appreciated by study of Table 1, based upon information furnished by Mr. C. C. Gove, Acting Assistant Postmaster-General. The carriage of express matter in cooperation with the American Railway Express Company has been in operation for only a few months, and the figures available to date on such traffic are of limited value. However, a report of the Department of Commerce (see Table 2) includes some estimates of the incidental traffic in packages carried by operators before the American Railway Express contracts became effective. Several of the routes are now carrying passengers and a limited volume of traffic is developing in this field also, although the operators have concentrated most of their efforts on the more lucrative fields of mail and packages.

The amount of civil flying in the United States has shown a steady increase in all branches, and a tremendous total mileage is now being accumulated. The report of the Asssistant Secretary of Commerce for Aeronautics, covering the first six months of 1927 and given in Table 3, indicates that regularly operated air routes in the United States are accumulating mileage at the rate of about 5,284,728 airplane-miles per year, without including their special trips and incidental flying. The operators of "aerial taxi" and similar services are now running at the rate of 18,746,640 airplane-miles per year, and the total operations of the two classes of service will reach the surprising sum of 24,755,866 airplane-miles per year if assumed to continue at the same rate for the next six months.

The most trustworthy estimates for European countries indicate that the combined operations of all regular air services on that continent in 1926 totaled about 9,316,509 airplane-miles during 1926. (These and other figures are given in Table 4.) As very little civil flying is done in Europe apart from the opera-

TABLE 3 TOTAL FLYING IN THE UNITED STATES DURING FIRST SIX MONTHS OF 1927

(Figures from U. S. Department of Commerce.)

	Miles flown	Passengers (*b*)
Scheduled flying by airway operators	2,642,364	1,891
Miscellaneous flying by airway operators	362,249	8,305
Flying by air-service operators, including aerial taxi and all other classes	9,373,320 (*a*)	385,450 (*a*)
Private owners	Unknown	Unknown
Manufacturers	Unknown	Unknown
Contests, races, meets, etc.	Unknown	Unknown
Known total	12,377,933	395,646
Year total on this basis of operations	24,755,866	791,292

(*a*) Estimated.
(*b*) Includes both those carried free and for hire.

TABLE 4 FLYING OPERATIONS ON AIR-TRANSPORT ROUTES OF THE WORLD FOR 1926 SO FAR AS AVAILABLE

(Scheduled services only.)

	Airplane-miles
Europe:	
German-operated routes	3,816,144[1]
French-operated routes	3,243,900
British-operated routes	840,000
Dutch-operated routes	597,500
Russian-operated routes	311,000[2]
Swiss-operated routes	210,340
Czechoslovakian-operated routes	170,895
Danish-operated routes	126,730
Total European	9,316,509
Other countries:	
United States of America	4,407,263
Canada	631,715[3]
Australia	417,964
World total	14,773,451

[1] All services suspended for 3 months due to financial difficulties.
[2] Incomplete figures.
[3] Including some non-scheduled flying.

[2] Compiled by Archibald Black, Garden City, N. Y. Mem. A.S.M.E.

tion of scheduled subsidized services, it is reasonably safe to assume that the total of all civil flying there did not exceed about 12,000,000 airplane-miles in 1926. From a comparison with Table 3 it is thus evident that the aircraft operators in the United States are flying as much in six months as all of the operators on the entire continent of Europe fly in a whole year.

The erroneous impression of European leadership in flying (which still persists in some quarters in the United States) may be due to the fact that European flying operations are based largely upon passenger transport. The visitor to Europe is therefore brought into more intimate contact with their activities than he is with American services.

The changes in air-transport equipment in the past year have been mainly along the lines of increased horsepower and greater carrying capacity, and in the very pronounced tendency to discard the converted war-surplus equipment in favor of modern designs. Air-cooled engines have become almost standard equipment in the operation of air routes, although many water-cooled engines are still in use among the "taxi" services. Indications are that the remainder of the water-cooled engines will be retired and superseded by air-cooled models in the near future.

Aerial Surveying

The Fairchild Aerial Surveys reports that technique has been developed for making a reasonably high-quality and reasonably accurate large-area map with a comparatively short-focal-length lens used at a high altitude. This means that the map can be produced with very few negatives, and as the negative rather than the square mile is the unit of production and of cost of the aerial photographic map, a low-cost map is secured which will serve most purposes.

Methods of calculating print scales in order to secure uniform accuracy both in short and long distances have been somewhat changed and materially improved, and this particular process cheapened.

The copies of the master mosaic made up of prints from aerial negatives have been improved, with the result that the finished map made of prints from these copy negatives shows finer detail and greater contrast, and is in every way more accurate, serviceable, and durable than previously.

A simple instrument has been originated and produced for platting the coverage on a map of obliquely taken pictures, commonly called "obliques," for determining the altitude and slope at which they should be taken and the proper map position of the airplane at the time of exposure.

The Aerocartograph, an instrument of German manufacture, invented by Dr. Hugershoff, has been developed for the purpose of securing greater utilization of data in aerial photographs and specifically for the accurate measurement of the parallax of objects at different altitudes, so that high-quality photographic maps may be made from the aerial negative with a minimum, if any, of field work in securing control elevations and distances.

Brock and Weymouth, in the field of engineering mapping, report the development of new instruments of precision and special methods by which topographic maps of engineering scale and accuracy are derived largely from aerial photographs, which are caused to yield all of the details of elevation, contour, location, culture, etc. Recent developments in this field have been the extension of these special processes to new limits of scale, both large and small, and corresponding varieties of contour interval. The development of the process has involved the design and construction of some interesting machines or precision instruments with which, for example, measurements of photographic parallax are made to the thousandth of an inch or less. The development has been well justified by utilization in various branches of engineering, such as power and water supply, irrigation, drainage, canals, transmission lines, pipe lines, etc.

Department of Commerce, Aeronautics Branch

Air Regulations as finally adopted and made effective on December 31, 1926, were the result of numerous conferences attended by representatives from every interested branch of aeronautics. They provided in detail for the licensing of pilots, mechanics, and aircraft. A medical director and about 200 physicians and surgeons have been appointed to give the physical examination for pilots. Fifteen men have been given appointments as pilot, aircraft, and engine inspectors. This nucleus is expected to reach the number of fifty within a year. A limited number of airplanes have been purchased by the Department to facilitate travel by inspectors. By the end of June, 1927, the Division of Air Regulations was fairly well organized, although the pressure of licensing work is tremendous owing to the continual increase in the number of pilots and planes in the United States.

The 1927 appropriation of $300,000 for air-navigation facilities was expended for the establishment of lighting facilities on 1386 miles of airways. Five routes were included in this mileage, all operated by air-transport companies carrying mail on regular night schedules that made flight in darkness necessary at some time during operations. The routes were New York to Boston, St. Louis to Chicago, Dallas to Chicago, Salt Lake City to Pasco, and Los Angeles to Salt Lake City. Thirty-two lighted intermediate fields were placed on the five routes, and 107 airway lights were established.

A radio equisignal range beacon for aircraft was established at Hadley Field, New Brunswick, N. J., and here experimental work has been conducted looking to the development of small airplane receivers suitable for single-pilot planes. Another radio beacon was installed on the transcontinental airway at Bellefonte, Pa.

Safety of navigation requires that information regarding landing and weather conditions be made available to air pilots approaching terminal fields, as well as periodic information as to changes in barometric pressures at points of known elevation for adjustment of the altimeter while in flight. Installation of radio telephones to communicate information of this sort to aircraft is being planned.

The Weather Bureau of the Department of Agriculture has established during the year, twenty-two new upper-air meteorological stations in addition to fifteen existing ones, many of which are located at airports. Weather data collected throughout the United States are transmitted to Weather Bureau offices twice daily, and forecasts of flying conditions are made available to pilots taking off at all terminal fields. A system of communication is being established under which the maintenance personnel on the airways will also furnish to the Weather Bureau forecasters information regarding local storms, fogs, and weather changes.

The airways follow the best flying country between designated airports, and have been determined after aerial reconnaissance. Intermediate landing fields, averaging about forty acres in extent, have been located about thirty miles apart between airports.

The airways are maintained under the general supervision of the Lighthouse District offices. Each airway is divided into sections, each section being in charge of an airway mechanician. For 4121 miles of lighted airways, 31 mechanicians and 161 caretakers were required.

Much was accomplished during the year in the improvement of airway apparatus and structures. The 24-in. rotating airway beacon has been improved by the addition of a flashing

mechanism for identifying lights, and the motor of the beacon is employed for the driving mechanism, thereby synchronizing the supplementary lights with the flash of the beacon. An improved and reliable lamp exchanger for the beacons has been developed commercially.

Airways structures have been numbered on a mileage basis for identification of location with respect to the airway. This numbering system has been incorporated in the lighting system in order that the distinctive characteristics may locate the beacon for the pilot aloft.

A flashing electric beacon using a 360-deg. Fresnel lens and top section showing from the horizon to the zenith, and so designed that equal candlepower is visible to the pilot approaching the light, is now being tried out on the Los Angeles-Salt Lake City airway.

Astronomic clocks have been introduced for the control of automatic lights.

Improvements have been made in the design of the internally lighted wind cone, making the device more reliable and eliminating the slip rings carrying current to the lights.

AIRCRAFT MATERIALS

In the employment of aircraft materials, the problem of protecting duralumin against corrosion has been attracting much attention. The anodic treatment of duralumin is meeting with success. The Aluminum Company of America has developed the material "Alclad," in which the duralumin is protected by an outer thin coating of pure aluminum for which corrosion need not be feared. In airplane fuselages for Army use there is a tendency to substitute chrome-molybdenum steel unheat-treated for the low-carbon steel used previously. Investigations are being made on the use of magnesium-alloy tubing and sheet for plane contruction. The B. F. Goodrich Company have developed a hard-rubber product termed "Aeroboard," suitable for use in hydroplane-float construction. The material approches wood from a weight-strength point of view, and eliminates soaking up of water.

AERONAUTICAL ACTIVITIES OF THE NAVY

Very satisfactory progress has been made in Naval aeronautical development during the past year. The Navy uses the following five types of aircraft: fighters; observation planes; combined scout, torpedo, and bombing planes; patrol planes; and training planes. Some years ago the Navy Department initiated the development of a line of three air-cooled radial engines of 800, 1300, and 1700 cu. in. displacement, corresponding respectively to 200, 425, and 525 hp. The 800-cu. in. engine is the Wright Whirlwind, which has been used so extensively in the last six years by the Navy and has recently come into such prominence in civil flying. The 1300-cu. in. engine is the Pratt & Whitney Wasp, which has recently established numerous world's records and is now in quantity production. The 1700-cu. in. engine involves two models, the Pratt & Whitney Hornet, which is similar in design to the Wasp, and the Wright Cyclone. Both of these engines are now in the limited-production stage. This line of engines was developed with the idea that the Whirlwind would be employed in the training-plane class, the Wasp in the fast single-and two-seat fighting and observation airplanes, with the Cyclone and Hornet in the scout, torpedo, and bombing field as well as the patrol field. Simultaneously with the development of the engines the design and development of the airplanes has gone forward. Naval aircraft must not be inferior in performance to any shore-based aircraft, and they must meet certain other limitations. They must have low landing speed for use on carriers and as seaplanes in rough water. They must be convertible from landplanes to seaplanes to enable their being launched from catapults or received on the decks of carriers. The superior performance of the air-cooled engine makes it possible to meet these requirements and still have superior aircraft. Aircraft of all the five classes have been thoroughly tested and have now gone into production. The Navy is now successfully using the Curtiss and Boeing single-seater shipboard fighters of high performance; the Vought Corsair two-seat observation airplane; the Loening amphibians; the Martin T4M; the Hornet engine in the combined scout, torpedo, and bombing area for single-engined airplanes; and the Douglas twin-engined torpedoplane around the Wright Cyclone. Direct and geared air-cooled engines are being rapidly installed in patrol planes of the PN-type, replacing the water-cooled engines. The standard training plane employs the Wright Whirlwind.

A commanding position in the matter of material is claimed. In case of war very large production around thoroughly proved and acceptable types of aircraft could be undertaken immediately.

AIRSHIPS[3]

The Aircraft Development Corporation of Detroit, during 1927, erected its small hangar for construction of the first ship MC-a, but lack of sufficient working capital and organization are responsible for the little construction done this year. About 15 per cent of the ship is built. The general design and layout for a 1,250,000-cu. ft. military ship are completed, but there is no order for it in sight until the first ship has been demonstrated.

The Goodyear-Zeppelin Corporation has completed the general design for a 6,500,000-cu. ft. military-training airship of most promising performance, and is continuing research work; but the actual construction is awaiting the Government contract. Details and arrangements of this design are the private property of the Navy and Goodyear-Zeppelin, and cannot be made public.

In England, the program of consistent research and the work of the Airworthiness of Airships Panel continues, and during the year has been supplemented by the test of a full-size section of the hull for one of the two 5,000,000-cu. ft. ships now under construction. Heavy-oil motors are being developed; and large hangers and mooring towers are being erected in Egypt, India, Australia, and Canada.

Germany has regained its freedom to continue the remarkable work which Count Zeppelin started almost 30 years ago. A 3,500,000-cu. ft. ship for Spanish-South American service is half completed, and it is the intention of the experienced firm building it to fly it around the world next year before it starts running on the first airship route in the history of transportation.

ALEXANDER KLEMIN, *Secretary.*

SUCTION DISKS have been successfully introduced for the purpose of lifting non-magnetic materials, such as glass, brass, copper, aluminum, and other plates. In the cranes made by the Demag A.G. of Duisburg, Germany, the load is gripped by means of a number of concave suction disks, the rims of which are fitted with a packing. These are placed on the sheet to be raised, the air within them is partly extracted, and the atmospheric pressure is utilized to create an adhesion exceeding the weight of the sheet. The electrically driven pump for the air extraction is mounted on the crane carriage and is connected to the suction disks by a flexible pipe.—*The Engineer*, Oct. 21, 1927, p. 455.

[3] Compiled by G. Betancourt, Airship Development Corporation, Detroit, Mich.

Progress in the Iron and Steel Industry

Contributed by the Iron and Steel Division

Executive Committee: F. C. Biggert, Jr., W. W. Macon, C. S. Robinson, Geo. T. Snyder

THE year 1927 was one of unusual achievements in the American iron and steel industry, among which two have attracted particular attention. The first was the manufacture of large seamless tubing the foundation for which was laid in the preceding year. It was during the current year, however, that the success of the undertaking was proved. The reasons for undertaking it are well known. With an increase in the depth of wells, complaints as to the strength of pipe then used came from the oil country, with an insistent demand for large-size, heavy-walled seamless tubing.

Manufacture of Large Seamless Tubing

Three companies have so far replied to this demand. One of these installed a German pilger mill, another provided both the German pilger and an American automatic mill, while a third limited its equipment to an American mill only. In all of these cases there was at first considerable doubt as to the ability to pierce billets of the size required for these machines. It was found ultimately that not only was there no trouble in regard to piercing, but that even rolled billets proved to be unnecessary and round ingots could be used as the raw material for the tubes. There are still certain mechanical problems requiring attention, but the success of the large seamless-tube mill in America has been decidedly established. As a matter of fact, greater production has been obtained in America from German mills than has ever been obtained in Germany.

Continuous Sheet Rolling

The other development which has attracted special attention is continuous steel-sheet rolling. This does not belong entirely to the current year, as the installations at Ashland, Ky., and at Butler, Pa., were substantially completed late in 1926. Such was the promise of these applications of continuous rolling of sheets, however, that several other mills of the same character have since been laid down, and some of them have been put into operation. Among these may be mentioned the mills of the Laclede Steel Co. at Alton, Ill., the Weirton Steel Co. at Weirton, W. Va., the Trumbull Steel Co. at Warren, Ohio, and the American Sheet & Tin Plate Co. at Gary, Ind.

The introduction of continuous sheet rolling has been accompanied by further development of the four-high mill and the use of roller bearings in the big rolls, thus further familiarizing the steel industry with anti-friction bearings in their larger aspects.

These two developments among others served to direct increased attention toward research among tonnage steel makers. To mention only the more prominent units, the Bethlehem Steel Co. had already segregated research and development work into a special department in 1926. This year the United States Steel Corporation organized a research department and has given it an unusually high standing by making it report directly to the Finance Committee, which is the highest governing body of the corporation. George Gordon Crawford, president of the Tennessee Coal, Iron & Railroad Co., and Prof. John Johnston, of Yale University, have been placed in actual management of the new organization, while to the committee deciding on the program of research have been attracted men of such prominence as Frank B. Jewett, vice-president of the American Telephone & Telegraph Co., and Professor Millikan of the Norman Bridge Laboratory, University of California.

Throughout the year the steel industry has been permeated with a certain feeling of unrest and search for economies. The amount of business done by the mills has been of almost record capacity, but prices obtained for the products have been comparatively low, and the general feeling has been that profits were not commensurate with the unusual volume of business. It has been felt, therefore, that the greatest attention to costs must continue without relaxation, to insure profitable operation in coming years.

Mill Drives

Steam as a means for driving the larger mills continued to lose ground. Among the outstanding electrifications of blooming-mill drive may be mentioned the installation of a 4000-hp. reversing motor at the plant of the Donner Steel Co. in Buffalo. A similar installation has been made by the Bourne-Fuller Co. at its Upson plant, while the Colorado Fuel & Iron Co. has put through an unusually ambitious project of electrification. In all these cases it is claimed that a better product is obtained at a lower cost. In the case of the Bourne-Fuller installation with the engine drive a maximum mill speed of 175 r.p.m. was obtained, and a speed of only 140 r.p.m. with a motor drive. It is not expected that as large maximum production will be obtainable from the electrified mill as before, but this is not considered important in view of mill and market factors modifying demands on the mill.

The progress made by powdered-fuel firing in central stations is making its way into the steel-mill field as well. At the Pueblo Works of the Colorado Fuel & Iron Co., powdered coal is used in the power plant. At the Central Iron & Steel Co. in Harrisburg, Pa., however, it is used in the heating furnaces of the plate mills. At first a unit pulverizer was installed, but later it was discarded and a central pulverizing plant is now used.

Rolling Mills

The size and capacity of modern mills are well illustrated by performance at the works of the Lukens Steel Co., Coatesville, Pa., where steel ingots weighing 63,000 lb. each have been converted into slabs on the 206-in. plate mill. This is believed to be a record for size of ingots rolled. According to *The Iron Age* for May 12, 1927, the ingot was rolled into a slab 130 in. wide, 200 in. long, and $8^3/_4$ in. thick. Each of these slabs is used to make a "flywheel" blank $8^3/_4$ in. thick and 121 in. in diameter, the blank being cut from the slab by means of a portable automatic oxyacetylene cutting machine. The blanks are to be used in making herringbone-gear speed-reduction units.

A new structural mill at the Homestead Works of the Carnegie Steel Co. has been completed. It includes a blooming mill of 54-in. size, claimed to be the largest blooming mill in existence. Another feature is that it is to roll the new wide-flange Carnegie beams. Only two operators will control the main or auxiliary drives of this blooming mill. One man using a single master switch is capable of setting the three screwdowns on the roughing and intermediary mills. They automatically stop at predetermined settings by means of a specially designed limit switch, and secure the proper speed relations between the motors driving the main and edging stands for any condition of draft. This man controls several other operations, thirteen in all, during the rolling of each beam, a fact which is a good illustration of

the complexity of the apparatus used and the resulting amazing simplicity and extent of control in operation.

In the past year the so-called Neuves-Maisons process for the heat treatment of steel rails has become known. This consists of an intermittent quenching of the head of the rail in a definite quantity of cold water, this quantity depending on the weight of the rail. It is claimed that this treatment increases the tensile strength and also extends the hardening effect beyond the depth of normal wear.

THE FOUNDRY FIELD

In the foundry field one of the interesting developments has been the application of hot blast to the cupola (H. K. Viall, *The Iron Age*, Oct. 20, 1927). In this case a standard cupola is used with only an upper wind box added below the charging floor. Carbon monoxide is drawn from the gases of combustion and used to preheat the air. Two years of operation have shown that combustion in the hot-blast cupola is more complete than in the cold-blast. Certain economies due to this more perfect combustion appear to have been established.

Further effort is being made in foundries to simplify and cheapen production, this being a more vital matter for foundrymen than ever before as castings today are in competition with forgings, stampings, automatic-machine products, and, finally, welded parts. In some directions castings have already lost out to welding. The latter has successfully replaced castings, for example, in large generators, parts of machine tools, etc. The foundry is meeting this situation in two ways. One is by permanent-mold casting, which has been applied, for example, to the making of Holley carburetors; the other is the employment of conveying devices. An interesting example of this latter class is the continuous unit for the manufacture of small gray-iron castings installed at the Elmira Foundry Co., Elmira, N. Y. (*The Iron Age*, Aug. 18, 1927.)

This report is only a general survey of the most important developments of the year, and no attempt has been made to cover progress in detail. This has been made necessary by the fact that the new Division is only just completing its organization.

ROY C. BRETT,
Organizing Chairman.

Progress in Machine-Shop Practice

Contributed by the Machine-Shop Practice Division

Executive Committee: L. C. Morrow, *Chairman*, Carlos de Zafra, *Secretary*, W. F. Dixon, J. H. Connolly, J. W. Hook, and W. W. Tangeman

ECONOMIC factors call forth the development of methods and equipment in any industry. It is equally true that pronounced advancement in production methods and equipment design affects economic trend. It is difficult to separate the two—to say where one leaves off and the other begins. Consider that important influence upon machine-shop practice during the past eighteen months—the almost universal recognition that successful competition depends quite as much upon the use of modern equipment as upon good management. Whether such recognition has done more to stimulate design than the new products of an inspired industry have done to obtain the recognition is a moot question, and for that matter is relatively unimportant. It is enough that the recognition does exist and that the metal-working industries have the advantage of lower production costs for the user, and increased equipment markets for the builder, of modern machine-shop equipment. It is significant that sales have been few among those equipment builders who have not modernized their product from the design point of view.

ECONOMIC FACTORS INFLUENCING THE METAL-WORKING INDUSTRIES

Similarly, there is a cooperative effect of the requirements of the equipment user and the inventive ability of the equipment builder that is revealed in more productive machines and tools with consequent mutual benefit in a business way. This condition is especially marked in connection with the automotive industry, wherein the search for ever lower production costs is a result of keen competition and the necessity for extremely large markets. It is not confined to the automobile builder, however, but extends firmly into any metal-working plant devoted to products made on mass production, and to a lesser extent into even the small-quantity, jobbing, and repair shops.

Because of the large markets required for our metal products it is advantageous that Europe is progressing toward economic stability. There have been worth-while improvements in business from England and Germany, and considerable improvement from France. Czechoslovakia remains a very good market, considering its size. South American consumption has increased. These statements apply to metal-working equipment and to automobiles.

Foreign markets are worth emphasis at this time because of the recession in the machine-shop-equipment business domestically during 1927—a recession not serious, but noticeable, and one that served to emphasize the over-capacity of the equipment shops, which has resulted in the extension of the lines of individual builders, thus multiplying the points of competition. To offset such expansion there have been few consolidations.

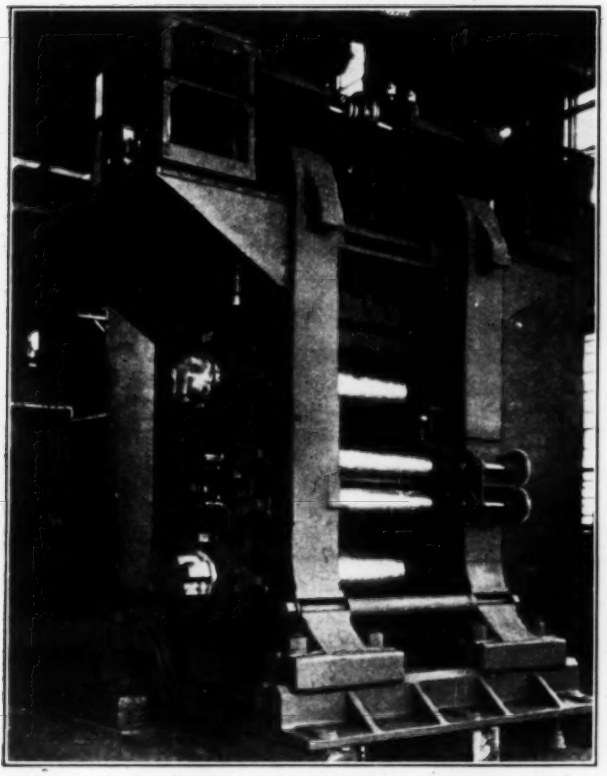
Other general factors affecting the metal-working industries are hand-to-mouth buying, increased commissions to dealers in some divisions of the industry, the requirement for sales engineers who are skilled in processing, the necessity for more accurate cost-accounting methods, and progress in standardization.

Hand-to-mouth buying has reduced inventories in some quarters and increased them in others. It has benefited the equipment builder in that respect, but has, at the same time, placed the premium of getting the business upon the ability to make prompt delivery. Thus the manufacturer with few lines and still fewer variations has had an advantage.

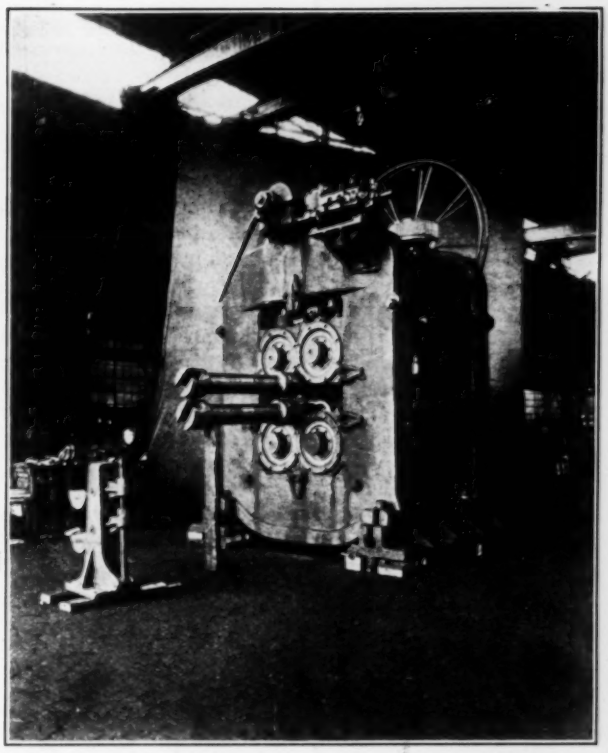
Increased commissions to dealers have raised the cost of sales, but have also spurred the dealers to increased efforts. Moreover, since not all of the increased cost could be passed to the consumer, on account of keen competition, the equipment builder has found it to his advantage to look to his own production methods and shop equipment.

The demand for sales engineers who are skilled in processing is a natural outcome of the search for better methods compelled upon the part of the user by competition.

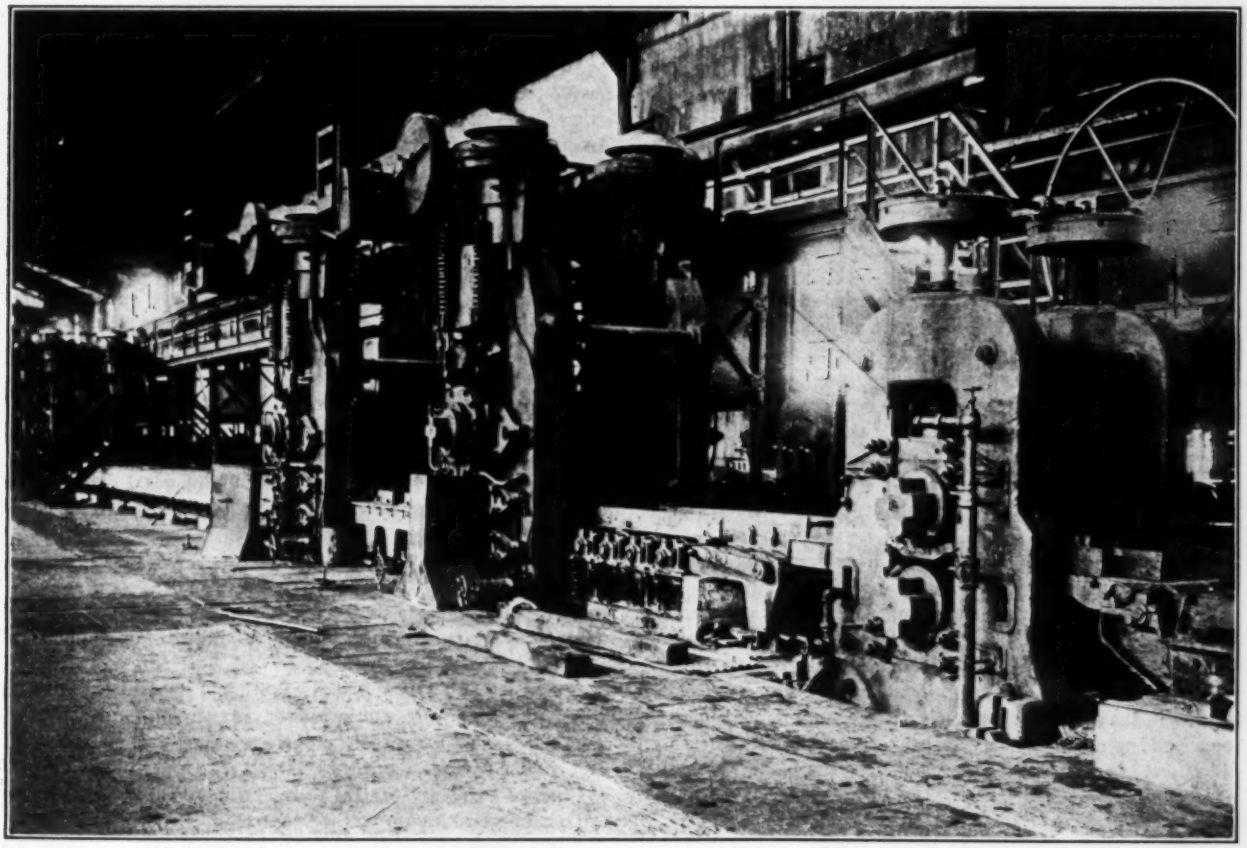
More accurate cost-accounting methods must necessarily accompany campaigns directed at the lowering of costs. De-



Four-High Mill



Cluster Mill



Four-High Mill at Trumbull Steel Co.

spite the fact that in principle, modern equipment has decided advantages over equipment several years old, there are cost-accounting problems that must be solved to the satisfaction of the guardian of the purse strings. For example, how much shall be allowed for depreciation and how much for replacement in view of the evident shorter economic life and increase in cost of equipment of advanced design, greater productive capacity, and better quality? This matter of cost accounting has assumed such large proportions that equipment builders are actually undertaking to educate equipment users in its fundamentals.

Standardization, not alone in metal products but in entirely disconnected lines, has influenced machine-shop practice. We are in an era of standardization and simplification that is reflected in all products. It is bound to have—and has had—an appreciable influence upon methods and equipment. The progress in the field dominated by the machine shop has had some notable examples of successful standardization. Akin to this movement and to the process of simplification is the elimination of waste, the outstanding results of which are already known, but which is being carried further by reductions in the cost of product by the substitution of pressed-metal and welded parts for those formerly made by more expensive methods.

PROGRESS AS INDICATED BY CHANGES IN MACHINE TOOLS

Most of the progress in machine-shop practice is indicated by the changes in machine tools. The first machine-tool exposition under the National Machine Tool Builders' Association, held in Cleveland in September, was therefore an index of such progress. The exposition was important also as further establishing a delayed buying period that had already become noticeable as a result of the expositions of the American Society for Steel Treating. The exposition of this year was the largest collection of machine tools featuring new design—and under power—ever displayed. Its influence upon the designing engineers of the builders and the production engineers of the users was most pronounced. It was a mart as well as a display. It thoroughly impressed the users of machine tools as to the extent and the solidarity of the machine-tool industry, and doubtless served to convince the machine-tool builder anew of the importance of his industry to civilization.

Progress in machine-shop practice, aside from the generalities just dealt with, can be shown best by a consideration of the details of changes in design of machine tools.

The demand of the machine user for greater strength, greater rigidity, and constantly higher speeds of production has been met by the builder with increase in weight, strengthening of critical sections, and a substitution of sturdier materials, especially in the more universal use of heat-treated alloy steels. Though the removal of great volume of metal is not of necessity a part of modern high-production methods, the ability of a machine to do so is, in a measure, a test of its capacity to withstand the shocks of high-pressure work without lowering its standard of accuracy and precision.

Anti-friction bearings have been incorporated extensively into the design of machine tools on rotating shafts, and in some cases on spindles, particularly on the spindles of drilling and grinding machines. Even on milling machines their use is quite common. At least one lathe builder uses them regularly on the spindle, and another supplies them as optional equipment. No standard practice in the application of anti-friction bearings has appeared. Some builders use only ball bearings, others only roller bearings, still others use both. On many machines the plain bearing has practically disappeared.

MACHINE DRIVES

It is becoming more common practice to connect the rotor shaft of the electric motor direct to the first driving shaft of the machine through some form of compensating coupling. In many of the machines having movements of adjustment in several directions a corresponding number of motors is used, each motor driving the particular unit upon which it is mounted without reference to or connection with the other parts of the machine.

The unit-drive method has led to the wider control of power traverse and power setting by push button, a control that has been developed to a point of great precision. Electric clamping, controlled by push button, also has been adopted when practicable, particularly for clamping the columns of radial drills.

In spite of the growth of the method of driving through direct connection of motor to driving shaft, the method of transmitting power by means of a short belt or some form of silent chain remains the most popular. It permits considerable latitude in the matter of speed ratios, works well upon even very short center distances, and operates without noise. A check-up of half of the machines at the machine-tool exposition showed that approximately 57 per cent were so driven. Another drive suitable for short center distances, and finding favor, is the multiple V-belt type. There are now several applications, and the indications are that its use will increase.

While the automobile-type disk friction clutch is more generally used, there exists a difference of opinion, some designers tending toward the positive clutch.

One of the greatest advances made has been in positive lubrication. In many machines all important bearings are oiled from a central reservoir by means of force-feed pumps. Both the circulating system, in which a continuous flow of oil to the bearing and back through a filter to the reservoir, and the intermittent system that supplies a drop of oil to each bearing at stated and easily regulated intervals, are used. Flood lubrication is rather generally applied to gear boxes. Pressure-gun greasing is used on many tools for isolated rubbing points. Full force-feed oiling of a whole machine has been accomplished; either a circulating or a "one shot" system is used for the purpose. An oil purifier, of the type used on automobiles, has been applied to at least one make of machine.

The hydraulic medium for transmitting power has been adopted to a surprising extent. It has been applied to the auxiliary feed and traverse movements, where it is of especial value because of its flexibility, easy control, and low liability to derangement and breakage. Particularly rapid strides have been made in applying this type of feed to drilling machines, grinders, and broaching machines, although other types, including milling machines, have been so equipped. Of the two hydraulic drives in common use, the cylinder-and-piston type is the more frequently applied, although in some of the larger machines, having long traverse movements, a hydraulic motor is connected directly to a pinion in mesh with a rack on the moving part. In this way there are no limiting factors in respect to length of movement inherent in the drive.

DEVELOPMENTS IN DESIGN

Other developments that apply to the machines of individual type, or to the machines of individual builders, can be described sufficiently by name only:

The actual and contemplated adoption of hardened steel ways.

The increased use of interlocking devices on control mechanisms.

The increased use of safety devices, shear pins, slip frictions and similar devices.

Changes in planer control to secure more rapid acceleration

Dynamic braking on voltage control.

Further trend toward automaticity.

Use of progressive assembly in building large machine tools.

Increased use of ground taps and very accurately finished chasers.

Contour planing and turning, using thin sheet templets, and with automatic electric control of the tool.

Cold-rolling of thin sheets and strips, by means of rolls of small diameter, without annealing.

DEVELOPMENT OF MACHINE TOOLS FOR USE IN THE AUTOMOTIVE INDUSTRY

Development of machine tools used particularly in the automotive industry deserves special mention, because of the influence of the industry upon machine-tool design in general, and because the automobile industry furnishes the greatest single market for machine tools. The developments have not been startling, in the way of new processes of a revolutionary nature, but changes have been constant, all tending in the direction of increased production and improved quality.

In machines such as the knee-type miller, there has been adaptation of the standard machine to special uses by means of additional spindles at whatever angle or in whatever position fitted the particular job in hand. In a somewhat similar way the special drilling head, with its spindles built to handle a particular job, and that job only, is being used in place of large multiple-spindle machines in which the spindles have to be adjusted for each set-up.

For certain types of drilling there has been considerable development along the line of three- and four-way drilling machines with enough spindles to drill all the holes in a transmission case or similar unit.

Turret lathes, both hand-operated and semi-automatic, are being more widely used. They have been improved by being provided with more substantial spindles and bearings, more convenient controls, and better lubrication.

The use of the grinding method of machining continues to increase, being particularly noticeable in connection with flat work and in honing. There is a noticeable tendency toward the adoption of the rigidly mounted hone, with the object of correcting out-of-roundness and taper. The latest types of machines on which the rigid honing heads are used provide automatic collapse and expansion of the heads. Originally designed for and used in the finishing of cylinder bores, the rigid-hone head is now being applied to the finishing of smaller holes, one example being piston-pin holes less than one inch in diameter.

A late addition to the line of crankshaft machinery is a lathe in which the shaft can be driven from the center while both ends are turned. A bearing is used between each two throws of the crankshaft.

ADVANCES IN GRINDING PRACTICE

Outside the automotive field, as well as within, the grinding process has been making great headway. New abrasives and new types of wheels have done much in the way of production. New bonds have permitted greatly increased speeds. Grinding of machine ways is an accomplished fact. Spindles are being subjected to an extra-fine grinding operation that gives a surface comparable to the best in automotive practice; considerably longer life is expected to result. Semi-automatic and full-automatic machines that put the work in place, perform the operation, and pass the finished piece on to the next machine are coming into the grinding field. In line with the general trend, more attention has been given to securing accuracy with a minimum of the operator's attention, even within remarkably close tolerances. Centerless grinding has made great strides, both in machine design and from the point of view of increased knowledge of the possibilities by the method. Semi-automatic, multiple-spindle, cylinder grinding has been developed. Worm-grinding machines have been introduced. Segmental grinding-wheel chucks have been placed on the market.

PROCESSES AND MACHINES OF THE YEAR

Certain processes and certain types of machines have come to the front during the past year.

Arc welding has been developed to the point where it is making possible the use of structural shapes and slab steel instead of cast iron and steel for motor and generator parts, for machine bases and for other products. Hydrogen-arc welding has been introduced as a practical process, and the shop equipment for its use has been developed. Welding machines as a whole have been developed, so that the process is much less dependent than formerly upon human skill, thus placing the process within the positive group, adaptable to production.

Jig-boring machines have been much improved during the year. The advances in design have been very favorably received, and in spite of prices relatively high in comparison with those of other kinds of equipment, have found a ready market. Their advent has placed many older and less accurate machines in the obsolete class.

A new method of dimensioning chamber sizes in rifle barrels and a standard method of making and checking chamber and barrel gages within 1/200 of 0.001 in. have been discovered. By the use of this method duplicate chamber plugs may be made by several gage makers, without variation among the gages of more than 1/4 of 0.0001 in. in diameter and with a variation of 0 in length.[1] It is obvious that these methods may be applied to gages for other classes of work, and may be instrumental in obtaining the extreme accuracy toward which the machinery industries are tending.

The casting of locomotive frames with cylinders integral by a middle-western manufacturer has given rise to a need for large machine tools to finish these castings. To perform the necessary machining there has been built a large milling machine to perform in one setting the operations that formerly required a large planer, a large slotter, and a cross-cutting planer. The redesign has effected a material saving in cost.

Equipment for producing accurate gears has progressed in design. The process of burnishing after cutting, and sometimes after hardening, is prominent. Additional equipment for inspecting gears also has been made available. One manufacturer has devised a machine for inspecting a gear and at the same time making a record of any inaccuracies, which can be analyzed to determine the characteristics of the gear.

Finishing of machine tools, other machines, and miscellaneous metal products is undergoing development. Finishing of machines by the spray method, usually involving the use of lacquers, has been adopted by several manufacturers. To some extent conveying equipment has entered into this process. The anodic oxidation of duralumin is one of the new finishes used on products.

The processes involved in heat treating have received marked attention during the year. Certain nomenclature has been adopted as standard. Time and temperature control has been made more exact. Steels and their treatments have been improved. Among the hardness-testing instruments introduced is one that measures the load required to cause a diamond ball to be impressed a given and constant distance into the material being tested, with provision for correction for errors due to contraction of the parts in the machine and the diamond when under strain.

Among the individual machines introduced during the year that point the way to what may be expected, are:

An "offset" milling machine, making use of a circular table

[1] A demonstration of this method was made by E. Pugsley at Frankford Arsenal and in New York City before the Technical Committee of the S.A.A.M.I.

on which the parts being milled surround a cutter of large diameter, the centers of the cutter spindle and the table spindle being eccentric. The object of this design is to engage a large proportion of the cutter with the work.

A push-broaching machine for broaching flat surfaces usually milled.

A turret lathe that has an ingenious hydraulic chuck-operating device actuated by the coolant pump, and using the coolant as the liquid medium.

An automatic vertical turret lathe.

STANDARDIZATION—RESEARCH

Standardization, though influential, did not progress as rapidly as it should have during the past year in the machinery industries. The outstanding accomplishment was the standardization of spindle noses and arbors of milling machines. Aside from its value as providing standards, it demonstrated what can be done in standardization work by an industry or group.

T-slot standards, adopted during the year, were heartily welcomed. Their full effect will not be felt for some time.

Other standards have been adopted, and progress has been made toward the determination of still others. Announcements from the committees and societies concerned, and by the technical press, have kept those interested informed.

Partial standardization of the principal dimensions of a.c. and d.c. motors has been accomplished in foreign countries. To some extent individual domestic manufacturers have progressed along the same line, making certain dimensions constant for a.c. and d.c. motors, but as a group the motor manufacturers have done little.

Of research work within the industry, there has not been a great deal. Progress reports issued from time to time have given information concerning the work on gears being conducted at Massachusetts Institute of Technology under the auspices of the American Gear Manufacturers' Association and The American Society of Mechanical Engineers. Studies have been in progress concerning oils and cutting tools. Study of dynamic and static balance has resulted in widening the field for balancing equipment beyond the balancing of automobile cranks and flywheels to the rotating parts of all kinds of machinery.

The activities of the Special A.S.M.E. Research Committee on Mechanical Springs during the year covered the organization of a financial cooperative group, the preparation of the bibliography for publication, and the layout of experimental work for the year 1927–1928. The personnel of the financial group numbers forty-five, twelve of whom are spring manufacturers and the remainder spring users. Each of these firms contributed an average of about $150 to the research fund. The committee is now starting the experimental phase of its program, several candidates for the position of Research Fellow, who will conduct the tests, having been interviewed. Copies of the bibliography will soon be available.

It is hoped that more will be accomplished by research during 1928. A committee for the purpose of instigating projects for research has been formed by the Machine Shop Practice Division. Machinery has been provided for getting the work under way after the committee has made its recommendations as to the work to be done, the laboratories available, and the personnel desired. It is expected that the value of the results to be obtained will then be so evident as to greatly assist in the collection of funds.

THE OUTLOOK FOR 1928

No one can predict with certainty what will be done during 1928. We may expect, however, to see progress along several lines, among them:

Still further use of hydraulic feeds and drives, anti-friction bearings, heat-treated alloy steels, pressed-steel and welded parts, automatic lubrication, safety devices, and automatic operation.

Development and adoption of more standards—for example, standards for nomenclature, initial machine speeds, motor speeds, electric-motor mounting dimensions, machine-tool capacity and performance, belt pull, and so on.

It is likely that foreman training, already well to the front, will be a subject of both experiment and progress during the coming year. It is gratifying that the foremen themselves are realizing the importance of their positions and are making persistent efforts to better fit themselves for their work.

There is still a feeling on the part of some members of the industry that skilled mechanics are no longer being made in quantities sufficient for the good of the industry. Other members feel that the supply is keeping pace with economic law—that the transfer of skill from man to machine has made relatively few mechanics necessary. No matter which viewpoint may prove to be the better, it is essential that the industry train boys for shop positions. From the ranks of these boys there will always emerge a number of skilled mechanics, who can be at least a nucleus on which to build in case of emergency. Others of the boys will become foremen. All of which indicates that attention should be given to apprentice training. There should be devised a system that will cause each manufacturer to contribute his share of skilled workmen and foremen to the industry.

There are predictions that at some time in the future we may expect radical improvement in cutting tools, an improvement which will cause the new tools to be so much more productive than those of today that the increased production will be comparable to that resulting from the introduction of high-speed steel. Whether such improvement will appear during the next year or within the next few years, is conjectural. The advent of a material, or a process, that would have such an effect would revolutionize machine-shop practice.

The activities of the Executive Committee of the Machine Shop Practice Division for the year consisted of the holding of sessions at the Spring Meeting and Annual Meeting; holding a joint meeting with the Metropolitan Section, at Newark; holding a National Meeting at New Haven in connection with the annual machine-tool exposition; the formation of a survey committee to instigate projects for research; and the preparation of this progress report. It is hoped that the service rendered to the machinery industries by these activities has been commensurate with the effort expended by the speakers and the Executive Committee.

L. C. MORROW, *Chairman.*

ON THE average each employee in our factories is now aided by more than $5000 of capital. It has been roughly estimated that the annual savings in the United States amount to about ten billions of dollars or approximately one-ninth of the national income.

The accumulation of capital is reflected in the great and increasing application of mechanical power. On the average each factory wage earner today is aided by 4.3 hp. of prime movers, a figure about double that in 1900.

Industrial units in the United States are much larger than anywhere else in the world and are steadily growing in size. Manufacturing plants with an annual output exceeding $1,000,000 each represent about only 5 per cent of the total number of establishments, but they contribute two-thirds of the total value of factory products.—E. Dana Durand, Chief of Bureau of Statistical Research, U. S. Department of Commerce, in *Iron Trade Review*, December 8, 1927.

Progress in Textile Mechanical Engineering

Contributed by the Textile Division

Executive Committee: James A. Campbell, *Chairman*, James W. Cox, Jr., *Vice-Chairman*, W. L. Conrad, *Secretary*, Chas. D. McEvoy, E. H. Marble, and McRea Parker

THE YEAR 1927 has without doubt been the best year for the textile industry since the post-war depression, and there is no reason why this condition should not continue. Many plants have liquidated, but this was to be expected, as no plant can continue to operate in these days of keen competition unless equipped with modern machinery and operated and managed efficiently. The need of modern management methods is more than ever a necessity in the industry. Plants which have adopted up-to-date methods are now enjoying the prosperity due them for this foresight.

Many cotton mills which had capital available when cotton was at low prices, have covered their requirements for the year, and are in an enviable position with cotton now selling at 23 cents. There is no doubt that many of these mills will experience the best year in their history. Current reports on the yield of cotton, at the time of writing this report, show the expected number of bales to be between thirteen and fourteen million. This is a considerable reduction from last year's bumper crop. No shortage is anticipated, however, due to the large carry-over from 1926.

Present available information indicates that there will be a large supply of wool.

Rayon Production

The rapid increase in the production of rayon shows that this material is being used in increasing amounts each year. Several more plants are being constructed to manufacture rayon yarns, and the future of this industry seems particularly bright. Some large cotton mills have made agreements and connections with rayon plants in order to assure a sufficient supply of these yarns to meet their requirements. The rapid adoption of rayon in various ways has caused many finishing plants to adapt their plants to handle these materials, the problems encountered having been overcome in an incredibly short time. Variation in the quality of rayon between different manufacturing plants, however, is still a serious problem, but it is to be hoped that rigid standards of quality and tests for the determining of the basic process will be developed in the near future.

During the first six months of 1927, consumption of cotton, wool, silk, and rayon in the United States reached the highest levels since the peak experienced during the war. The following figures show increases over the first six months of 1925.

	Jan. 1–July 1, 1926	Jan. 1–July 1, 1927
Cotton.....	3,392,990 bales	3,803,992 bales
Silk.....	237,043 bales	275,060 bales
Wool.....	240,449,000 pounds	279,904,000 pounds

From available figures, over 36,000,000 lb. of rayon was consumed during the first six months of 1927. It seems safe to predict that the world's production for the year will be in excess of 240,000,000 lb.

Figs. 1 and 2, taken from the *Textile World*, give the production of rayon in the United States and in the world, as well as consumption in the United States from 1921 to 1926 and estimates for 1927. These charts clearly show the increase in production and consumption.

With better methods employed in the manufacture of fabrics and the elimination of price cutting (frequently putting the sale price below the cost of production), there is no reason why the industry should not come up to its former position among the leaders.

There is continual agitation to reduce the working hours of employees, therefore, to keep abreast of the times, machines

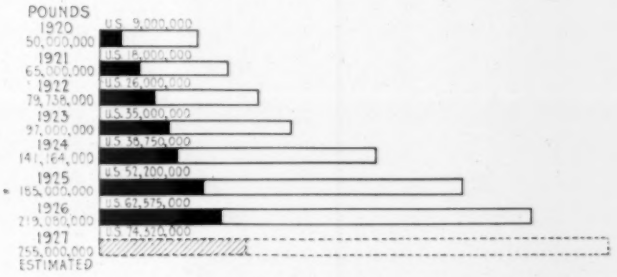


Fig. 1 United States and World Rayon Production by Years

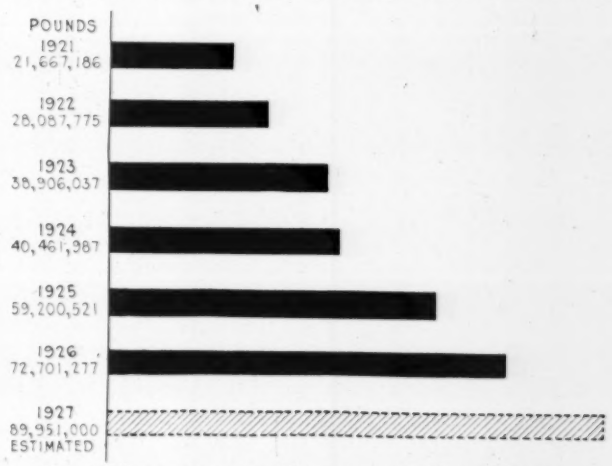


Fig. 2 Consumption of Rayon in the United States
(Represents domestic production plus imports.)

must be improved so that production can not only be maintained but increased.

Significant Developments in the Textile Industry

Significant developments in the textile industry for the present year are as follows:

1 Expansion of the rayon industry.

2 Use of rayon in increased quantities in the many branches of the industry.

3 Increased production o ffine-count rayon and silk-mixture materials in Southern mills.

4 Improvement in processing of all- or part-rayon fabrics in finishing plants.

5 Recognition that the economics and policies of the past are now inadequate for present-day competition.

Many mills are reorganizing their plants and doing away with obsolete machinery and methods. This is more noticeable in the New England field, and promises great developments

and results. The close competition of today has been largely responsible for the interest that manufacturers have now begun to show in proper machinery, equipment, and manufacturing conditions.

6 Partial elimination of price slashing, putting part of the trade on a sounder basis.

This latter condition has been to a great extent brought about by the Cotton Textile Institute. It is the first time on record that a majority of mill men in any branch of the industry has been able to get together on a cooperative basis for the study and improvement of manufacturing and merchandising conditions. The work of the Cotton Textile Institute will no doubt be of incalculable value to this branch of the industry. A similar institute for the woolen and worsted branch should prove even more beneficial. The Whiteside plan, which has the cooperation of a large portion of this branch, may be of great value.

Machinery and Processes

Among the important developments in machinery and processes may be mentioned the following:

Improvement in cleaning and handling of low-grade cotton, making possible the use of grades two or three lower than commonly used heretofore for given counts and qualities of yarn.

Increased production per operative and machine.

Continued progress in operating more machines in range in cotton-goods finishing plants.

Considerable reduction in the cost of operation of cotton-goods bleacheries by introduction of more labor-saving machinery.

Increased use of individual motor drives on looms.

Preference in the use of automatic looms.

Increased use of variable-speed motors, especially on washing machines.

Development of the dual-clip tenter chain so that two rolls of cloth can be tentered at the same time on one machine.

Increased use of cork covering on front rolls in worsted spinning mills.

Research

A considerable amount of general research has been started, and it is hoped that the organizations which have been formed will later pool their results. It is absolutely essential that a central organization be selected to publish results. There are no means at present to prevent several committees from working on the same research problems. Studies have been made, both on cotton and wool, which later should be of benefit to the industry. The results of growing cotton from the same seed in different soils, and the changes which have developed in the different fibers produced in these varying conditions, have been of interest.

Effect of Developments in Other Fields of Engineering

The recognition of management engineering in the textile field will have an important effect upon the industry. Management engineering should, however, be carried on by engineers who thoroughly understand this work.

It is important that young and enthusiastic engineers be trained in this work, so that in the near future it will be possible for these men to take over the teaching of textile management engineering in our textile schools. The result will be that these schools will graduate men who will look on textile management as work of vital importance.

The progress in steam engineering has been of great benefit to the textile industry. Increased use of powdered fuel has been noted—also increased use of exhaust steam for processing.

Account should also be taken of the development of aviation and its requirements in textile fabrics; and of the development of the oil engine, which will no doubt find its place, especially in cotton spinning mills.

Future Trend in the Field of Textile Engineering

From a mechanical standpoint the following developments may be expected:

Much lighter-running machinery and electrical controls of the automatic type.

Increased installation of roller bearings on all types of textile machines.

Elimination of steam-engine drives.

Application of modern methods in management, giving greater economy in mill control and more accurate cost finding.

Continued improvement in machinery, and increase of labor-saving machines.

The American textile manufacturer must eventually come to the realization that the old "hit or miss" methods must be done away with, and a more regular product be produced. Frequently manufacturers attempt to manufacture a product which has been developed in another mill. The cost of such experimenting adds greatly to the overhead burden, and often in striving to produce a similar fabric at a lower price, costly changes are made in the plant which cause a fabric having an established place in the market to be again supplanted by a cheaper and poorer one.

The reduction in taxes in the New England states will somewhat assist plants in reducing their losses. If the plants are equipped with modern machinery and properly managed, there is no reason why they should not be able to compete with Southern mills on certain fabrics.

Future developments and improvements in the industry will depend largely upon the vision, effort, and cooperation of those actively engaged.

There are many opportunities for young engineers in the industry. Promotion may not be as rapid as in other industries, but there are many places at the top which can be reached by men who have initiative and the ability to surmount the difficulties common to all manufacturing plants.

JAMES A. CAMPBELL, *Chairman.*

High-Pressure Gas Research

IMPORTANT developments are taking place in the facilities for high-pressure gas-research work in Prof. W. A. Bone's department at the Imperial College of Science and Technology, London. With increased resources two new high-pressure gas research laboratories are now being equipped. In one there will be accommodation for high-pressure explosion-bomb installations and two pressure-catalytic tube units. In the other there will be means and apparatus for preparing, storing, and compressing gases, for the determination of compressibilities, for the calibration of standard gages, etc. Outside the building there will be a 3000-ft. and other smaller gasholders, and an experimental gas-generating plant. When complete the equipment will include two gas compressors, one working up to 200 and the other up to 1000 atmospheres pressure, a wide range of explosion bombs, capable of withstanding explosion pressures ranging from 100 up to 20,000 atmospheres, and catalytic-tube units capable of withstanding pressures up to 500 atmospheres at 500 deg. cent. Most of the equipment will have been installed by the end of March, 1928. A limited number of post-graduate research students will then be enabled to undergo a course of training, extending over two years or so.—*The Engineer*, Nov. 18, 1927, page 555.

Progress in the Woodworking Industries

Contributed by the Wood Industries Division

Executive Committee: Wm. Braid White, *Chairman*, Paul H. Bilhuber, *Secretary*, James S. Mathewson, Sern Madsen, and Thos. D. Perry

DURING the past year the wood industries of the United States have shown, by and large, a growing interest in the fundamental question of the quantity and quality of the remaining supplies of domestic timber. In part this interest has been due to the work of the National Committee on Wood Utilization, which was set up three years ago by Secretary Hoover of the Department of Commerce, and which is composed of representatives of the lumber, woodworking, forestry, and engineering interests. The A.S.M.E., in the person of the present chairman of the Wood Industries Division, is represented on this committee, which is working to educate the wood industries in eliminating waste, in the need for an understanding of scientific methods of timber conservation, and in preparing the way for the ultimate adoption of standards in machinery and in machine methods. The work of this committee is by no means the only work of the kind being done, but it must be mentioned as a contributing factor to the year's progress.

Not enough has become known among the industries, metal and non-metal alike, concerning the very fine work which has been going on for a number of years at Madison, Wisconsin, where the Forest Products Laboratory of the Forestry Service of the United States carries on its increasingly valuable researches into every aspect of the growth and use of wood. The practice of throwing open to technical men from the woodworking industries free courses at the Laboratory in the gluing of wood, in the science and art of plywood building, in crating and boxing, and especially in the seasoning and drying of lumber, has been continued, and it may confidently be affirmed that all who have had personal contact with these admirable courses of instruction feel more than repaid for the time spent in them. If the woodworking industries were more alive to the work which the Forest Products Laboratory is doing, they would be insistent in pressing Congress to be more generous in appropriating the needed funds.

Timber Conservation

Timber conservation is no longer a matter merely of academic interest. At the annual convention of the National Lumber Manufacturers' Association, held this summer in Chicago, the tone of the discussions was extremely serious, indicating clearly that the lumber men, who have been the chiefs corners of all talk about diminishing supplies, are themselves already thoroughly alarmed at the situation. This fact lends point to the position taken by the Wood Industries Division of the A.S.M.E., which two seasons ago undertook to investigate the situation as to possible supplies of commercially and industrially usable timbers from tropical countries, such as the Philippines, British India, and Central and South America. In the Progress Report of one year ago it was possible to say something briefly about this research, and now, a year later, it can be stated that some quite definite steps have been taken. A comprehensive bibliography of books, papers, and articles in several languages, upon every aspect of the tropical-woods question, has been prepared by Major George P. Ahern and Miss Helen Newton of the Tropical Plant Research Foundation of Washington, D. C. In addition to this extremely valuable pioneer work, which is paving the way for the scientific investigation of a subject as important as it is little understood, the Wood Industries Division has given special attention to presenting aspects of the question at various meetings of the Society. Thus, at the first national wood industries meeting of the A.S.M.E., held last November in Chicago, after the 1926 Progress Report had been written, the whole question of timber supply was taken up by Major Ahern, whose paper produced valuable discussions and debates, in which experts from the Forest Products Laboratory, tropical foresters, and representatives of large wood-using industries took part. At the second national wood industries meeting of the Society, held in Grand Rapids during the month of October last, the same subject was taken up again, and has come to general attention.

Research

Last year's report made mention of a project to secure a research into the properties of machine saws and cutting blades, investigating the laws governing the behavior of these tools in use, and leading to the formulation of recommendations to manufacturers and users whereby closer agreement may be arrived at in regard to saw cuts, sharpening, standardization of cutting edges, etc. Considerable difficulty was experienced in obtaining a working committee, but the task has now been accomplished and the first general meeting will have been held before this report has been published.

The research in spark-arrester design and use is proceeding through the help and cooperation of the Pacific Coast Local Sections of the A.S.M.E.

Progress in Developing Woodworking Machinery Along Engineering Lines

Last year some mention was made of the subject of woodworking education, with special reference to the attitude assumed by directors of technical schools and colleges. It is not possible at this time, unhappily, to say anything more encouraging than was said a year ago. Woodworking remains, in the minds of engineering educators, the cut-and-fit art it was a generation or two since; nor is there much probability of fruitful change save through the direct intervention of the woodworking industries, and their insistence upon a proper appreciation of the fact that woodworking has now perforce been driven into the engineering ranks.

Meanwhile it is possible to say something more or less definite about the progress which has been made during the year in developing woodworking machinery along engineering lines.

In the first place, there can be no doubt as to the trend of design of woodworking machinery. It is toward inbuilt electric motors, rendering each machine self-contained. In the same way one may note a trend toward the adoption of multiple-operation machines, while frequency changers are being more and more used to give machines the advantage of both high- and low-speed operation. This practice is becoming more and more common in connection with shaping, grinding, jointing, and (some types of) planing machines.

Another new departure is to be found in the gradual invasion of the field by tools driven by compressed air, and some newly designed shapers and routers so driven are being successfully

exploited. The primary cost of compressed-air operation is greater than where electric current is used, but the maintenance cost is sufficiently lower to offset this in most cases.

The use of high-speed steel for cutter heads and milled knives is also developing, and in shapers, matching, and molding machines cutting tools made of this material are rapidly replacing the older carbon-steel types.

It is worth noting that the speed and accuracy of woodworking machinery are often underrated by engineers who are not closely in touch with modern mill developments. The fact that wood is a material relatively easily worked sometimes is allowed to obscure the equally important fact that woodworking machinery is keeping all the time a little ahead of its material and is constantly being adapted to closer, more accurate, and more rapid operation. Even if the factor of rapidity be left out of the picture, it is certain that all these developments make in their way for conservation of a timber supply already dangerously depleted.

Turning again for a moment to this question of the supply of the raw material of woodworking—the timber itself—it is interesting to note that in addition to the movements mentioned at the beginning of this Report, others have been initiated by the lumber interests. Among these may be mentioned:

1 Completion and adoption of the American Lumber Standards for softwood, thereby unifying sizes, grades, and shipping practice in respect of by far the greater part of all such lumber annually produced in this country;

2 Steady development of hardwood grading standards;

3 National waste-prevention contests, bringing out new machinery, methods, and suggestions for preventing waste, using materials now being wasted, and improving the quality of the product from the log; and

4 Adoption of a research program covering the properties and uses of wood.

Wood Finishes

In the domain of wood finishing, it is worth noting that the use of nitrocellulose solutions (known as "lacquers") in the place of varnishes has been steadily increasing during the past year. More than half of all the furniture exhibited at the winter and summer furniture shows this year was lacquer-finished. The difficult technical problems of applying these new finishes to woods are gradually being worked out, and woodworkers are coming to regard lacquer as not merely interesting and novel, but as definitely valuable and advantageous when rightly prepared, applied, and managed. It is distinctly pleasing at this point to discover that one result of the growing interest in these lacquer finishes is to be found in definitely improved work in the sanding of wooden parts as they come from the mill, in preparation for the application of the lacquer. Clean and smooth sanding is necessary when lacquers are used, and of course there are numerous other subsidiary advantages to the finished product, flowing from this improved practice.

The research into the possible use of tropical hardwoods, reported here as part of the work of the Wood Industries Division of the A.S.M.E., is being backed up practically by certain woodworking industries, which report trials, and in some cases adoption, of tropical hardwoods in place of domestic varieties, but the subject is still in too indefinite a shape for more positive comment.

Plywood continues to find favor where strength and resisting power are factors, and the art of fashioning it continues to become more exact, thus tending to the utilization of woods which otherwise in many cases have been wasted.

The evolution of the wood industries into engineering arts proceeds steadily, and the place of the woodworking technicians among the members of the A.S.M.E. becomes yearly more thoroughly justified.

Wm. Braid White, *Chairman.*

The World's Timber Supply

IN A PAPER on this subject presented at the Leeds meeting of the British Association last October, Prof. Fraser Story pointed out that over 80 per cent of the demand for timber was for softwood. The conifers which produced softwoods were practically confined to temperate zones and to North America, Northern Europe, and Siberia. In the United States, the lumbering activity centered in the West, and the resources could not hold out for more than twenty to thirty years. The once heavily timbered regions of eastern Canada had been cleared of almost all large-sized timber, and the small softwoods were seriously threatened by the demand for paper pulp. According to official statistics, three-quarters of the merchantable timber of Canada had already gone. Apart from America, 75 per cent of the world's softwood area was located in Northern Europe and Siberia. In Europe as a whole, the annual consumption of 9000 million cu. ft. exceeded the growth by about 3000 million cu. ft. Most of the coniferous forests of Northern Russia were in sparsely populated, inaccessible regions and the difficulties of economic exploitation were equally great in Siberia. The newsprint of the world had demanded 350,000 tons of timber in 1913, and now consumed little short of 2,000,000 tons a year. The growth of timber was slow and uncertain. At the present rate, the virgin coniferous forests of the world could not last more than 37 years. Even with improved forest protection and timber utilization, serious shortage of softwoods and rises in prices were threatening and might develop suddenly, and Great Britain would be one of the first countries to suffer.

Similar considerations were submitted by R. S. Pearsons, director of Forest Products Research, in his paper on Utilization of Soft Woods; Developments and Improved Methods. Mr. Pearsons also examined the reasons which prevented architects and builders from favoring home timber, i.e., the quality of the timber, the scattered nature of the forests, their limited areas and the consequent difficulties of securing large supplies of uniform grades. To meet these difficulties, large forest areas would have to be created in this country, and the intense utilization of suitable timbers should further be studied in Forest Product Research Laboratories by investigating the anatomical structure of wood, its strength factors, working properties, and protection against deterioration. A further contribution to the problem was made by A. C. Forbes, director of Forest Research, Ireland, in his paper on the Maintenance of Permanent Softwood Supplies in Northwestern Europe. Among his suggestions were better protection of forests against fires, etc. the conversion of unprofitable hardwood areas into coniferous forests, the afforestation of land of low agricultural value, the substitution of reinforced concrete, plywoods, and pulpwood from hard timber for softwood, and an adequate state control of all forest land.

Prof. A. W. Borthwick pleaded for the afforestation of water-catchment areas. Climates, he stated, controlled forest growth, but the forest reacted on the climate. The forest was perennial; the leaf canopy killed other vegetation underneath, except some shrubs and mosses; the falling leaves covered the soil with a humus layer. A rain gage placed under the leaves would catch 75 to 85 per cent of the precipitations; the rest would trickle down the trees or evaporate. An area of meadow grass consumed more water daily than a forest area.—*Engineering*, Nov. 4, 1927, p. 573.

The Influence of Elasticity on Gear-Tooth Loads

Progress Report No. 9 of the A.S.M.E. Special Research Committee on Strength of Gear Teeth[1]

THIS progress report is the second of a series of analyses of the test runs made on the Lewis gear-testing machine, using the various equations developed in the previous progress reports to test their consistency, and deals with the runs made with cast-iron gears.

VI TEST RUNS WITH CAST-IRON GEARS

All of these runs with cast-iron and semi-steel gears were made with the solid pulleys attached to the pinion shaft. Many runs were made in the attempt to check the reactions on the master gears as well as to check the conditions at the critical speeds. In general, it was much more difficult to obtain satisfactory breaks in the telephone receivers on the runs with cast-iron gears than it was with the hardened and ground steel gears. Many duplicate runs were made to test the consistency of the results. A selection of typical runs has therefore been made which cover the range of speeds tested as the complete logs are so extensive and contain so much duplication.

Each gear received has been marked with a symbol, the first figure representing the diametral pitch and the second, the number of teeth, while the third is an arbitrary serial number assigned in the order of the receipt of the gears.

Run L

Test pinion..... 3-18-9
Test gear..... 3-48-3
Semi-steel gear and pinion
Measured error..... 0.0023 in.
Tooth form same as on hardened and ground gears.

$y_1, y_2 = 0.110$ $R_1 = 8.000$
$z_1, z_2 = 0.10582$ $d_t = 0.00000126\,f$
$m_a = 19.25$ $p = 1.0472$
$m_p = 0.50$ $f_a = \dfrac{f_1 \times f_2}{f_1 + f_2}$
$m_2 = 1.00$ $f_1 = 0.00055\,mV^2$
$E_1, E_2 = 15{,}000{,}000$ $f_2 = 1825 + f$
$R_1 = 3.000$

The log of Run L is given in Table 1, together with the calculated values for the effective masses, acceleration loads, amounts of separation, and impact loads.

TABLE 1 LOG OF RUN L AND CALCULATED DATA

Run No.	V	f	m	f_a	k	P
L- 25	166	39	0.906	13.9	0.000792	263.8
L- 26	209	54	0.891	20.8	0.000847	328.8
L- 27	232	65	0.883	25.6	0.000858	369.5
L- 28	258	78	0.873	31.5	0.000872	415.6
L- 30	326	118	0.850	48.7	0.000862	536.9
L- 32	410	130	0.823	73.2	0.001187	641.7
L- 34	527	184	0.786	113.2	0.001255	816.8
L- 39	612	229	0.760	145.9	0.001263	944.2
L- 42	632	270	0.754	153.8	0.001085	1003.6
L- 44	642	314	0.750	157.5	0.000906	1055.7
L- 46	645	337	0.748	158.5	0.000822	1080.8
L- 48	698	374	0.733	180.0	0.000817	1164.6
L- 49	756	392	0.718	205.1	0.000889	1232.8
L-130	792	356	0.710	220.3	0.001113	1225.0
L-131	902	436	0.679	268.0	0.001035	1388.2
L-132	906	458	0.679	270.6	0.000970	1414.3
L-133	920	488	0.675	276.5	0.000897	1454.2
L-134	1163	550	0.623	387.5	0.001102	1674.8
L-151	897	513	0.680	266.7	0.000785	1463.1
L-150	1112	644	0.629	364.8	0.000767	1738.8
L-149	1218	696	0.607	413.8	0.000774	1852.1
L-148	1280	914	0.588	444.1	0.000406	2105.9
L-147	1477	731	0.564	535.2	0.000976	2021.9
L-146	1600	783	0.545	592.7	0.000965	2129.8
L-145	1630	835	0.539	607.9	0.000870	2194.4
L-144	1675	1027	0.523	629.0	0.000519	2405.2
L-143	1681	1096	0.522	634.8	0.000410	2478.1
L-142	1900	1218	0.493	738.5	0.000345	2684.5
L-141	2022	1305	0.478	800.2	0.000279	2816.2

Run M

Test pinion..... 3-18-10
Test gear..... 3-48-10
Cast-iron gear and pinion
Measured error..... 0.0033 in.
Tooth form.....$14\frac{1}{2}$-deg. composite form.

$y_1 = 0.086$ $m_2 = 1.00$
$z_1 = 0.09936$ $R_1 = 3.000$
$y_2 = 0.110$ $R_2 = 8.000$
$z_2 = 0.10582$ $d_t = 0.00000130\,f$
$E_1, E_2 = 15{,}000{,}000$ $p = 1.0472$
$m_a = 19.25$ $f_1 = 0.00055\,mV^2$
$m_p = 0.50$ $f_2 = 2538 + f$

The log of Run M is given in Table 2, together with the calculated values of the effective masses, acceleration loads, amounts of separation, and impact loads.

TABLE 2 LOG OF RUN M AND CALCULATED DATA

Run No.	V	f	m	f_a	k	P
M- 34	172	47	0.914	14.9	0.001012	321.5
M- 36	269	90	0.885	34.5	0.001198	507.1
M- 38	379	132	0.853	65.3	0.001526	704.1
M- 40	595	237	0.795	146.8	0.001831	1087.6
M- 46	656	291	0.779	172.7	0.001703	1211.1
M- 48	745	329	0.757	213.8	0.001840	1348.2
M- 49	896	423	0.722	288.0	0.001844	1597.7
M- 50	1335	649	0.638	523.2	0.001964	2191.7
M- 52	1350	705	0.631	529.6	0.001762	2256.0
M- 53	1860	733	0.560	804.0	0.002570	2586.0
M- 58	2265	823	0.516	1015.9	0.002713	2850.0
M- 63	1545	617	0.604	633.7	0.002565	2294.0
M- 64	1708	649	0.581	721.1	0.002724	2421.4
M- 65	1730	698	0.577	734.4	0.002516	2482.8
M- 69	1860	796	0.558	805.4	0.002292	2650.7
M- 70	1870	931	0.550	810.7	0.001810	2761.2
M- 72	1900	969	0.549	831.5	0.001738	2847.9
M- 74	2280	925	0.512	1029.0	0.002326	2966.5
M- 91	715	369	0.763	200.2	0.001480	1357.2
M- 92	881	378	0.726	280.3	0.002065	1536.9
M- 95	1108	405	0.680	397.1	0.002719	1768.2
M- 94	1225	499	0.657	459.9	0.002441	1955.6
M- 96	1520	705	0.605	621.6	0.002085	2366.0
M- 97	1745	812	0.572	744.9	0.002055	2607.3
M- 98	1758	839	0.570	752.9	0.001977	2642.0
M- 99	1960	839	0.546	860.1	0.002264	2742.7
M-103	2310	846	0.512	1040.7	0.002677	2895.9
M-104	2513	950	0.493	1148.3	0.002469	3074.2

[1] The personnel of the A.S.M.E. Special Research Committee on the Strength of Gear Teeth is as follows:
Wilfred Lewis, *Chairman*, President, Tabor Manufacturing Company, 6225 Tacony Street, Philadelphia, Pa.
Carl G. Barth, 420 Whitney Avenue, New Haven, Conn.
Earle Buckingham, Professor, Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.
Ralph E. Flanders, Manager, Jones & Lamson Machine Company, Springfield, Vt.
Arthur M. Greene, Jr., Dean, School of Engineering, Princeton University, Princeton, N. J.
Clarence W. Ham, Professor of Machine Design, University of Illinois, 115 Transportation Building, Urbana, Ill.
Charles H. Logue, *Secretary*, Consulting Engineer, 123 Clarke Street, Syracuse, N. Y.
Fred E. McMullen, Manager Cutter Department, The Gleason Works, Rochester, N. Y.
Edward W. Miller, Chief Engineer, Fellows Gear Shaper Company, Springfield, Vt.
Ernest Wildhaber, 379 Alexander Street, Rochester, N. Y.

RUN BA

Test pinion..... 2-16-1
Test gear..... 2-32-1
Cast-iron gear and pinion
Measured error..... 0.0048 in.
Tooth form.....14½-deg. involute

y_1	= 0.081	m_2	= 1.00
z_1	= 0.09768	R_1	= 4.000
y_2	= 0.102	R_2	= 8.000
z_2	= 0.10404	d_t	= 0.00000132 f
E_1, E_2	= 15,000,000	p	= 1.5708
m_a	= 16.67	f_1	= 0.00055 mV^2
m_p	= 0.68	f_2	= 3636 + f

The log of Run BA, together with the calculated values of the effective masses, acceleration loads, amounts of separation, and impact loads, is given in Table 3.

RUN CA

Test pinion..... 2.5-12-1
Test gear..... 2.5-48-2
Semi-steel gear and pinion
Tooth form.....14½-deg. involute
Measured error.....0.0023 in.

y_1	= 0.067	m_2	= 1.37
z_1	= 0.09206	R_1	= 2.400
y_2	= 0.110	R_2	= 9.600
z_2	= 0.10582	d_t	= 0.00000136 f
E_1, E_2	=15,000,000	p	= 1.25664
m_a	= 21.52	f_1	= 0.00085 mV^2
m_p	= 0.39	f_2	= 1691 + f

The log of Run CA, together with the calculated values of the effective masses, acceleration loads, amounts of separation, and impact loads, is given in Table 4.

RUN CB

Test pinion..... 4-24-1
Test gear..... 4-64-1
Cast-iron gear and pinion
Tooth form.....14½-deg. involute
Measured error..... 0.0029 in.

y_1	= 0.096	m_2	= 1.00
z_1	= 0.10222	R_1	= 3.000
y_2	= 0.114	R_2	= 8.000
z_2	= 0.10651	d_t	= 0.00000128 f
E_1, E_2	= 15,000,000	p	= 0.7854
m_a	= 19.25	f_1	= 0.00041 mV^2
m_p	= 0.50	f_2	= 2265 + f

The log of Run CB, together with the calculated values of the effective masses, acceleration loads, amounts of separation, and impact loads, is given in Table 5.

When testing the accuracy of these gears, a considerable difference was found in the form of the tooth profiles on opposite sides. A second series of runs was, therefore, made with the pinion turned around. In this case all values are the same as before except that the measured error = 0.0016 in., whence $f_2 = 1250 + f$.

The log of this run with the pinion turned around, together with the calculated values as before, is given in Table 6.

RUN CC

Test pinion..... 4-24-2
Test gear..... 4-64-2
Semi-steel gear and pinion
Tooth form.....14½-deg. involute
Measured error.....0.0022 in.

TABLE 3 LOG OF RUN BA AND CALCULATED DATA

Run No.	V	f	m	fa	k	F
BA- 1	228	114	0.906	25.8	0.001007	546.3
BA- 2	265	122	0.897	34.7	0.001278	623.1
BA- 3	315	185	0.885	48.4	0.001125	776.1
BA- 4	405	218	0.864	76.5	0.001523	959.9
BA- 5	455	251	0.853	94.6	0.001620	1075.0
BA- 6	500	294	0.843	112.7	0.001617	1192.2
BA- 7	570	342	0.827	142.7	0.001738	1350.9
BA- 8	670	390	0.806	190.5	0.002026	1551.4
BA- 9	700	408	0.800	205.0	0.002074	1611.6
BA-10	720	426	0.796	215.9	0.002079	1660.1
BA-11	1400	744	0.680	628.6	0.003214	2787.0
BA-12	1700	802	0.642	830.7	0.003875	3115.0
BA-13	1890	860	0.620	959.6	0.004082	3321.3
BA-14	1925	918	0.615	983.8	0.003842	3404.9
BA-15	740	402	0.793	225.6	0.002345	1663.1
BA-16	835	505	0.773	277.1	0.002200	1897.3
BA-17	940	588	0.753	337.6	0.002240	2118.0
BA-18	1250	630	0.702	529.8	0.003327	2520.0
BA-39	752	570	0.788	232.4	0.001518	1849.7
BA-40	770	631	0.784	241.5	0.001359	1933.4
BA-41	889	671	0.761	308.2	0.001668	2135.1
BA-43	902	752	0.758	315.5	0.001439	2233.4
BA-44	958	827	0.747	348.5	0.001380	2380.9
BA-45	1690	979	0.640	826.6	0.002946	3287.5
BA-46	2270	1311[1]	0.578	1232.2	0.002882	4039.2

[1] Pinion showed signs of distress.

TABLE 4 LOG OF RUN CA AND CALCULATED DATA

Run No.	V	f	m	fa	k	F
CA- 1	128	28	1.221	16.8	0.001354	265.8
CA- 2	153	43	1.203	23.7	0.001230	325.2
CA- 3	167	52	1.194	27.5	0.001171	355.7
CA- 4	185	65	1.181	33.4	0.001126	399.4
CA- 5	208	70	1.165	42.0	0.001315	444.5
CA- 6	233	72	1.148	51.5	0.001571	486.1
CA- 7	259	88	1.130	62.7	0.001549	544.2
CA- 8	294	100	1.107	77.5	0.001674	606.1
CA- 9	333	130	1.081	96.6	0.001572	693.4
CA-10	404	130	1.038	133.4	0.002179	788.3
CA-11	426	141	1.025	145.5	0.002175	827.1
CA-12	392	147	1.045	126.6	0.001807	789.1
CA-13	370	166	1.057	115.3	0.001430	779.7
CA-14	455	166	1.007	161.6	0.002019	887.3
CA-15	472	183	0.997	171.7	0.001924	925.8
CA-16	488	231	0.986	181.1	0.001550	992.6
CA-17	546	300	0.951	215.0	0.001340	1125.3
CA-18	565	300	0.941	226.0	0.001413	1144.8
CA-19	561	308	0.943	223.8	0.001351	1148.5
CA-20	570	308	0.938	229.3	0.001387	1158.1
CA-21	638	392	0.899	270.6	0.001194	1309.7
CA-22	705	461	0.863	312.1	0.001100	1440.2
CA-23	711	474	0.860	316.0	0.001068	1458.0
CA-24	835	671	0.794	392.7	0.000733	1755.3
CA-25	806	790	0.798	372.1	0.000427	1805.2
CA-26	870	948	0.760	412.5	0.000234	2053.4
CA-27	868	1422[1]	0.723	403.0	−0.000391	2514.1

[1] This last load at limit wear load on pinion. No breaks were heard in the telephone receivers.

TABLE 5 LOG OF RUN CB AND CALCULATED DATA

Run No.	V	f	m	fa	k	F
CB- 1	219	47	0.905	17.9	0.001070	331.2
CB- 2	343	62	0.872	41.3	0.001874	492.6
CB- 3	379	70	0.863	49.9	0.002000	539.4
CB- 4	384	75	0.861	50.9	0.001898	552.5
CB- 5	425	88	0.850	61.4	0.001940	612.0
CB- 6	533	139	0.823	92.3	0.001797	779.0
CB- 7	558	150	0.817	99.7	0.001789	814.8
CB-10	642	188	0.796	128.0	0.001799	938.9
CB-11	670	207	0.789	137.0	0.001729	982.8
CB-13	734	254	0.782	161.9	0.001620	1095.2
CB-14	795	291	0.760	182.9	0.001563	1182.6
CB-16	1162	511	0.683	332.7	0.001423	1692.9
CB-17	1335	545	0.654	408.5	0.001629	1842.6
CB-18	1390	569	0.644	432.2	0.001629	1900.0
CB-19	1515	614	0.624	487.6	0.001662	2018.2
CB-20	1565	637	0.617	510.9	0.001656	2069.6
CB-21	1680	637	0.601	560.7	0.01740	2099.6
CB-22	1715	680	0.595	577.3	0.01713	2191.6
CB-23	1775	725	0.586	604.1	0.001630	2264.9
CB-24	1815	900	0.576	624.5	0.001159	2461.5
CB-25	1960	945	0.558	690.0	0.001190	2573.2
CB-26	2030	1017	0.549	723.4	0.001083	2675.7

TABLE 6 LOG OF RUN CB AND CALCULATED DATA
(With pinion turned around)

Run No.	V	f	m	fa	k	F
CB-26	166	30	0.904	9.9	0.000507	187.2
CB-37	197	42	0.893	13.9	0.000500	227.9
CB-38	273	58	0.878	19.7	0.000502	279.0
CB-39	305	62	0.854	32.2	0.000781	343.9
CB-40	336	77	0.843	37.9	0.000726	382.4
CB-41	371	88	0.831	45.4	0.000754	421.8
CB-42	413	120	0.816	54.7	0.000637	485.8
CB-43	595	135	0.760	101.9	0.001072	629.4
CB-44	632	160	0.749	113.1	0.000977	679.5
CB-45	641	160	0.748	115.7	0.001001	685.1
CB-46	775	173	0.710	155.8	0.001240	777.3
CB-47	715	164	0.718	135.6	0.001146	730.3
CB-48	778	184	0.709	156.8	0.001160	790.1
CB-49	970	432	0.652	219.2	0.000463	1137.9
CB-50	1050	488	0.632	245.6	0.000414	1231.2
CB-51	1170	526	0.606	285.4	0.000432	1320.3
CB-52	1180	601	0.600	289.4	0.000297	1400.3
CB-53	1070	884	0.603	249.9	−0.000159	1634.5

These gears are duplicates of those used in Run CB except for the difference in material. All factors are the same as for Run CB except that $f_2 = 1718 + f$.

The log of this run, together with the calculated values as before, is given in Table 7.

These gears also showed a difference in the two sides of the tooth profiles so that a second series of runs were made with the pinion turned around. All values are the same as before except that the measured error = 0.0030 in., whence $f_2 = 2343 + f$.

The log of this run, with the pinion turned around, together with the calculated values as before, is given in Table 8.

SUMMARY

The calculated amounts of separation on these gears show much greater variations than on the hardened and ground steel gears. Also the amounts are greater than before. In general, the cast-iron gears show greater amounts of separation than the semi-steel gears.

Under test, the profiles of the cast-iron gears became covered with an appreciable black coating which probably had an influence on the amount of separation required to break the electrical circuit. This also probably accounts in part for the greater difficulty in obtaining satisfactory readings during the tests. The semi-steel gears also had a similar coating, but it was not so heavy. Even when the teeth were cleaned before making a run, a very few minutes in operation was sufficient to change the clear oil into a black paste, and introduce this coating again.

On two of the runs (BA-46 and CA-27) the surfaces of the tooth profiles began to show signs of distress. When this condition occurred, it was impossible to get any satisfactory reading on the gears. This condition was probably caused by a load that imposed stresses in the material beyond its strength.

TABLE 7 LOG OF RUN CC AND CALCULATED DATA

Run No.	V	f	m	f_a	k	F
CC- 1	158	31	0.915	9.0	0.000617	206.9
CC- 2	183	36	0.907	11.9	0.000702	237.9
CC- 3	222	55	0.895	17.8	0.000673	301.7
CC- 4	254	69	0.885	22.7	0.000675	347.5
CC- 5	361	89	0.853	44.9	0.001038	479.2
CC- 6	359	92	0.853	43.9	0.000978	473.0
CC- 7	397	100	0.842	52.4	0.001071	521.1
CC- 8	440	115	0.830	63.7	0.001122	578.5
CC- 9	468	131	0.821	71.2	0.001087	620.7
CC-10	560	151	0.796	96.7	0.001273	719.4
CC-11	627	182	0.778	117.3	0.001253	806.1
CC-13	688	204	0.762	137.4	0.001292	877.6
CC-14	856	260	0.721	195.5	0.001394	1056.4
CC-15	1250	401	0.638	342.8	0.001436	1431.2
CC-16	1355	516	0.617	384.2	0.001125	1599.6
CC-17	1540	625	0.585	457.8	0.000997	1792.5
CC-18	1520	725	0.584	450.9	0.000725	1885.0
CC-19	1718	725	0.557	528.3	0.000893	1964.0

TABLE 8 LOG OF RUN CC AND CALCULATED DATA
(With pinion turned around)

Run No.	V	f	m	f_a	k	F
CC-23	162	31	0.921	10.0	0.000946	247.3
CC-24	171	37	0.919	10.9	0.000858	262.8
CC-25	190	47	0.914	13.9	0.000854	301.3
CC-26	228	60	0.904	18.9	0.000903	357.1
CC-27	293	77	0.886	30.6	0.001135	454.5
CC-28	363	96	0.868	46.1	0.001365	558.6
CC-29	450	137	0.846	68.1	0.001382	697.9
CC-30	575	153	0.815	150.4	0.001922	847.9
CC-31	656	191	0.796	132.7	0.001903	968.6
CC-32	632	191	0.801	124.6	0.001783	945.1
CC-33	701	204	0.785	148.8	0.001988	1025.9
CC-34	775	284	0.768	176.3	0.001611	1175.8
CC-35	873	384	0.745	214.4	0.001355	1363.6
CC-36	1130	488	0.694	321.7	0.001530	1673.4
CC-37	1610	610	0.615	535.4	0.001942	2100.2

It is proposed to make further tests on the gears at various speeds to determine how great a load the gears can carry at different speeds when these signs of distress appear. Thus the condition of the tooth surfaces themselves will be used as a measure for comparison.

Tests have been made on gears of various materials up to this limiting load and speed condition. The next progress report will therefore examine the results of these tests.

A Liquid-Film Seal for Hydrogen-Cooled Machines

ONLY a very brief abstract of this interesting paper can be given here. Hydrogen may be efficiently used as a cooling medium for large electrical machines. As a rule, however, it is necessary to have one or both ends of the shaft project through the gastight casing. Consequently some form of seal is required around the shaft which will effectively prevent the outward leakage of hydrogen from the machine and also prevent any appreciable inward leakage of air.

It is claimed that a satisfactory seal has been developed on what may be called the liquid-film principle. Essentially it is an arrangement where the shaft passes through a stationary sealing ring of small clearance from the hydrogen side to the air side of the machine casing. Oil or other liquid under pressure is distributed around the shaft by an annular feed groove and forced to flow axially through the small clearance between the shaft and sealing ring. In this manner a complete film of liquid is maintained which constitutes an effective seal for both stationary and running conditions. The remainder of the article deals with the ability of the seal to withstand the gas pressures involved, as well as calculation of power consumption by the seal, oil flow, and temperature rise. Leakage tests with air and hydrogen are reported in considerable detail, and a table on solubilities of hydrogen and air in transformer oil is included. Data given would indicate that a liquid-film seal of the vacuum or double-grooved type using oil constitutes a rugged, gastight seal for high-speed machines. (Chester W. Rice, in *General Electric Review*, Nov., 1927, pp. 516–530, 17 figs.)

Alloy Steel in Modern Locomotives

THE increased capacity of modern locomotives has taxed to the limit the physical properties of straight carbon steel as a material for certain locomotive parts. Many roads have already attacked this problem by the adoption of alloy steels for such important parts as main and side rods, crankpins, axles, and piston rods. Some railroads have had experiences with certain alloy steels that were so directly opposed to the results anticipated that they have abandoned the use of these materials and returned to straight carbon steel. Other railroads have utilized these steels very successfully. When it comes to the question of why there was failure in some cases, it would appear that this was due either to selection of improper steels or their improper manufacture, in melting, forging, and heat treating. In the case of railroads particularly, the steels used, namely, chrome-vanadium, chrome-nickel, and carbon-vanadium, are sensitive alloys which react favorably or otherwise in direct relation to the accuracy of the several stages of the heat-treating process. In adopting these materials some of the railroads did not prepare for their use by installing adequate heat-treating facilities in their repair shops and providing a trained personnel. (*Railway Mechanical Engineer*, Nov., 1927, p. 707.)

A German Powdered-Coal-Fired Locomotive

OF LATE a locomotive of this type built by the A.E.G. has been tested in freight service near Berlin. Externally the locomotive does not differ much from the conventional type except that the tender is completely enclosed and instead of coal carries a boiler-like container filled with powdered coal. No details of construction, and particularly of burners and methods of delivering coal from the tender to the burner, are described. It is stated, however, that the tests were very successful. (*Wärme und Kälte Technik*, Oct. 19, 1927, pp. 277, 1 fig.)

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AIR ENGINEERING

The Ellison Wind Motor

THIS motor is the invention of Hubbard Ellison, of London, Ont., and utilizes curved metal sails and shields together with what is claimed to be a novel drive assemblage for actuating the shaft. It has an upright cylinder with curved vanes and a gear hub attached to the bottom plate of the rotor, which at once drives the power gear and a lower governor gear. A retarding windshield on the wind side is so arranged that only certain vanes are actuated by the wind, depending on its direction. A general illustration is given, but no special details of construction or data of tests. (W. E. Elliott in *Canadian Machinery and Manufactureng News*, vol. 38, no. 20, Nov. 17, 1927, pp. 19 and 31, 3 figs., *d*)

AVIATION (See Internal-Combustion Engineering)

FUELS AND FIRING

A New Coking Process

DESCRIPTION of a carbonizing process developed by Prof. S. W. Parr and T. A. Layng, of the University of Illinois, and now in commercial operation by the Urbana Coke Corporation, Urbana, Ill. The coal is crushed so that the largest pieces are about pea size. After passing through the preheater, in which it undergoes the first step of the carbonizing process, it passes into a preheated storage bin. The oven is of the horizontal recuperative coke-oven type as designed by the Russell Engineering Co. and holds one ton. Firing is by producer gas made in a producer attached directly to the oven setting. The gas passes through an offtake to a combined cooler, condenser, and scrubber, where tar and liquid are removed to storage. It is then mixed with the carbureted water gas produced by the local gas company.

The preheating treatment is apparently the key of the process. It removes moisture from the coal and by partial heating increases the output of the oven. It also, however, removes the oxygen in the form of CO_2, and this makes it possible by this process to coke coals that cannot be coked by other processes. No figures as to costs of the process are available. Low grades of coal can be used, however, and it is said that the quality of the product is good. [Graham L. Montgomery (Mem. A.S.M.E.), Assistant Editor of *Chemical and Metallurgical Engineering*, in *Chemical and Metallurgical Engineering*, vol. 34, no. 11, Nov., 1927, pp. 668–669, *d*]

Efficient Utilization of Fuel in Iron and Steel Works

AT THE Technical Institute, Middlesbrough, on Nov. 14, 1927, H. E. Wright delivered his presidential address to the Cleveland Institution of Engineers. There were two points of view on the subject of utilization of fuel in iron and steel works, the speaker said. The fuel economist has one point of view to save fuel, while the plant man tries to carry on his business profitably and has to save fuel to do this.

The regenerative coke oven loses for the blast furnace 31 per cent of the heat in its fuel, but its working is superior to the others. The by-product coke oven appears to be a commercial proposition only, while iron manufacturers are prepared to pay more for heat units potential in coke than for equal potential heat units in raw coal. The by-product coke oven cannot exist without absorption of its coke by iron manufacturers unless a new use is found for metallurgical coke at the old prices. In the blast furnace 50 per cent of the fuel exists in the gases still to be used, and where impure ore, etc. make fuel consumption high, 70 per cent exists unconsumed in the gases. Except for hot blast nothing enters a blast furnace which does not leave it hotter than it entered. The only inference it is possible to draw from this is that any increase of material leads to loss of heat and in consequence fuel.

From the point of view of fuel economy the correct way to reduce fuel consumption in a blast furnace is to reduce input of material to the lowest point. Instead of this it seems probable in certain cases that the blast furnace is overwhelmed with input and then criticized as inefficient.

The author discusses in detail the reactions in the blast furnace from the point of view of their influence on fuel economy, and also takes up the matter of reduction of iron and descent of materials. The descending materials absorb heat from the ascending gases and return it to the hearth. While the nitrogen in the hearth is at 1500 deg. cent., it is found at only 300 deg. cent. in the gases. There exist according to the author's opinion four main methods of reducing the fuel consumption of the blast furnace. 1, In any way possible, lower the thermal needs per ton of pig; 2, increase blast heat if possible; 3, select material easily reduced by the gases and see that it is in form and condition for the gases to reduce the iron in it right to the core; and 4, prepare the materials so that they will descend regularly and uniformly so as in all ways possible to be able to absorb the fullest possible amount of heat from the furnace gases and keep the furnace free with that object in view.

The subject of utilization of furnace gases comes next for discussion. When gas (without cleaning it) is used to heat blast stoves, the combustion of gas owing to the large combustion chamber is quite good and the heat loss at the chimney valve is quite low. Loss of heat by radiation could be largely cut down by coating stoves and gas mains with non-conducting material, but the main prospect of saving lies in lessening the number of stoves. This requires clean gas and reconstruction with closer checkers; in fact, the use of gas here might be reduced to about 25 per cent of the total. This would be a material saving, but not too large a saving considering the cost of cleaning the gas, etc. to save it.

When it comes to utilizing blast-furnace gases in gas engines, the author thinks that to turn the blast furnace into a gas producer is not economical, because there is the loss in coking coal, and with a given blowing plant the output of a furnace is almost inversely in ratio to the use of fuel per ton of pig.

Passing on to the steel works, the author considers primarily the basic open-hearth furnace and claims that some of the fuel, the use of which in the basic open-hearth furnace is criticized by the fuel economist, is compensated for by direct reduction of iron which is characteristic of the process. It is no more than superstition to imagine that the consumption of fuel is governed

entirely by the quality of the gas as shown by gas analysis. A gas good analytically has to have more air to burn it; a bad gas, less. So in combustion they are level, because gas is made only to be burned. The producer gas must, however, always be maintained at a standard in combustibles high enough to meet the requirements of the steel furnace. While improved analysis above the minimum will not necessarily save any fuel, gas below standard will lead to very serious losses. The producer top should be kept cool to save radiation losses, also the piping to the furnace. Furthermore, hot gas heats up the inlet to the regenerator, which becoming the outlet on reversal, causes high chimney loss. The use of proper fuel is the most vital factor in producer work. There is there a layer of fuel through which air should be propelled or drawn uniformly. Patches of shale or inferior coal burn out rapidly and let air pass. To prevent this the air has to be reduced, whereupon there is a chance to start partly uuconsumed flow through the rest of the bed. (H. E. Wright in an address to the Cleveland Institution of Engineers, abstracted through *The Iron and Coal Trades Review*, vol. 115, no. 3116, Nov. 18, 1927, pp. 739–740, *gp*)

INTERNAL-COMBUSTION ENGINEERING

Competition Between Central-Station Interests and Diesel-Engine-Driven Municipal Plants

ACCORDING to a statement published under the title, "Power Interests Attack Oil Engine," a central station company in Minnesota (The Interstate Power Comapny) by advertising tried to prove that the Diesel engine is not economical and under certain conditions not sufficiently reliable. A page advertisement is reproduced with arguments attempting to show that the allegations made by the power company are not correct. (*Oil Engine Power*, vol. 5, no. 11, Nov., 1927, pp. 737–740, *g*)

The Farman Inversed 550–700 Hp. Aviation Motor

THIS is an 18-cylinder W-type motor arranged in three sets of six cylinders at an angle of 40 deg. The dimensions are such that a light gasoline without benzol or alcohol additions may be used. The cylinders are cast en bloc in sets of six, symmetrically with respect to the longitudinal axis of the group but slightly inclined toward the interior of the cylinder; each cylinder is provided with two inlet and two exhaust valves. These valves are operated by a single camshaft carrying four cams per cylinder. The camshaft is driven by a train of gears from the crankshaft, the intermediate gears driving the water pump, the oil pump, the gasoline feed pump, and the magnetos. The crankshaft is of the seven-bearing type and is machined completely in a lathe. The original article gives curves showing the operation of this engine, such as power at full throttle, fuel consumption, etc. (*L'Aerophile*, vol. 35, no. 19–20, Oct. 1–15, 1927, pp. 314–316, illustrated, *d*)

Fuel Tests of the Fairchild Caminez Engine

THESE tests were carried out in part on a Waco-10 plane powered with a model 447-B cam engine developing 135 hp. at 1000 r.p.m. In this flight a cruising speed of 80 m.p.h. was maintained at an average propeller speed of 725 r.p.m. Thirty-five gallons of gasoline were consumed during this 7-hr. flight. For the second test the gasoline capacity of the plane was increased to 110 gal. The plane was flown with a considerable load, but not at constant propeller speed, for a period of 17 hr. 20 min. The hourly consumption of gasoline was 4.9 gal. In this engine there is no gearing or auxiliary valve-actuating mechanism, the push rods being driven directly from the main camshaft which takes the place of the crankshaft in the usual crank engine. The cam principle of this engine secures half the propeller speed at the same piston speed of the crank engine without using gear reduction. The cam engine therefore operates at slow propeller speed, and the large-diameter, slow-speed propeller is said to be more efficient and hence to permit lower fuel consumption. (*Aviation*, vol. 23, no. 19, Nov. 7, 1927, pp. 1114–1116, *e*)

The Börner Triple-Chamber Engine

AN ENGINE of very unconventional design has recently been developed by A. Börner, an engineer of Dresden, Germany. As shown in Fig. 1, this engine consists of a cylinder divided into what amounts to three independent combustion chambers with two pistons connected by a rod and arranged in such a manner that the upper piston is substantially double acting while the lower is single acting. An essential feature of the engine is that the interconnecting piston rod is oil cooled. Each of the three chambers is equipped with its own admission and exhaust valves and its own spark plug. Each works on the four-stroke cycle, but their combination, particularly for a multicylinder engine, is quite involved, and, for example, in a four-cylinder engine is equivalent to that of a 12-cylinder engine of the conventional type. It does not appear that any such engine has been actually built, and no data of operation are presented. The inventor is well known, however, in German engineering circles. (*Maschinen-Konstructeur*, vol. 60, no. 20, Oct. 31, 1927, pp. 474–476, 4 figs., *d*)

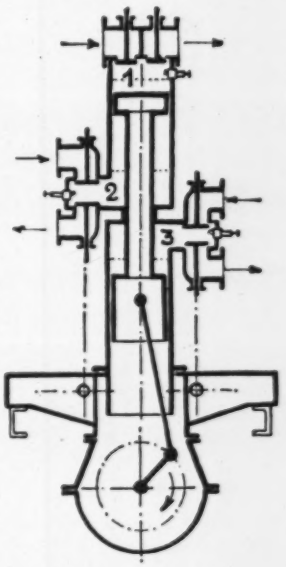


FIG. 1 DIAGRAMMATIC VERTICAL SECTION OF ONE CYLINDER OF THE BORNER TRIPLE-CHAMBER ENGINE

The Zoller Supercharged Double-Piston Two-Stroke Engine

THE Zoller engine is built at the works of the Chapuis et Dornier Co., near Paris. It is a four-cylinder engine with eight cylinder bores, each pair of bores having a common combustion chamber. There are also eight pistons and eight connecting rods, and yet the overall length of the engine is less than that of a normal four-stroke of equivalent piston displacement though the width is slightly greater. There is a master connecting rod with roller bearings at the crankpin and a secondary rod attached to the main rod. The two cylinder barrels are parallel, having a bore of 38 mm. (1.496 in.). While having a parallel motion, the stroke of the two pistons is not uniform, and it is this feature which enables the engine to operate on the two-stroke principle with the supercharger without the use of valves or a distributer.

At upper dead center the two pistons are on the same level, but one piston descends more rapidly than the other, and in its stroke uncovers the exhaust port in the cylinder walls before the opposite piston has uncovered the inlet port. This gives a lead to the exhaust opening, and allows the exhaust port to be covered again by the piston before the fresh charge is admitted into the companion cylinder.

With the normal two-stroke engine having a deflector piston it is not possible to supercharge, for the exhaust ports have to be higher than the inlet ports, and the exhaust closes later than the

admission. To overcome this difficulty, use is sometimes made of inlet valves in the head of the cylinder, while ports are used for the exhaust. While there are advantages in scavenging the cylinders, the exhaust closes very late, and the fresh mixture has to be sent into the cylinders under high pressure after the exhaust has closed. Further, the use of valves causes the engine to lose some of the advantages the two-stroke naturally possesses over the four-stroke.

The supercharger is built in with the flywheel and is of the rotary type. It is entirely contained within the flywheel housing. While the present engine is designed for ordinary mixture supply from a carburetor, it can be also produced as a Diesel or semi-Diesel engine. (*The Autocar*, vol. 59, no. 1671, Nov. 11, 1927, pp. 1021–1022, 5 figs., *d*)

A Differential-Stroke Internal-Combustion Engine

DESCRIPTION of the Andreau variable-stroke motor, giving for the first time more or less complete information. The principles of this motor were described in MECHANICAL ENGINEERING, vol. 47, no. 4, April, 1925, p. 292.

In this motor, which is now being handled by the Citroën Motors Company, the mechanism first used for varying the stroke is said to have proved a great obstacle to commercial success; however, the problem was finally solved by the employment of a pair of Citroën gear wheels. By the use of these gears a relatively simple mechanism has been evolved, with the further advantage that two crankshafts revolving at different speeds are available for power transmission. The engine as now built has a single cylinder with a bore of 85 mm. (3.35 in.); the length of the admission stroke is 63 mm. (2.48 in.), and that of the firing stroke 128.5 mm. (5.05 in.). Air cooling has been adopted. At normal running speed the upper crankshaft revolves at 700 and the lower 1400 r.p.m. These figures can be reduced by about 25 per cent without increasing the consumption of fuel. At the higher speeds the engine develops 4½ hp. with a fuel consumption of 0.379 lb. per hp-hr.

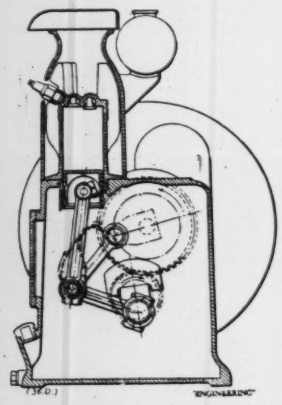


FIG. 2 TWO-CRANKSHAFT DRIVE, MECHANISM OF THE ANDREAU-CITROEN VARIABLE-STROKE ENGINE

It will be seen in Fig. 2 that the two crankshafts are coupled by a two-to-one gear, the gear wheels being of the Citroën double-helical type. The big end of the connecting rod is coupled to the two crankpins by links, of which there are actually two lower and two upper. The small ends of the lower links are mounted on a central pin, their outer surfaces forming the bearing for the connecting rod. The small ends of the upper links bear on the outside of the connecting-rod big end. The lower crankshaft is a one-piece forging and the link to which it is connected has a split end, but as the upper crankshaft is built up, the link bearing in this case is solid. The gudgeon pin is gripped in the connecting rod, and is free to turn in the piston, a practice which is being increasingly adopted for high-speed engines. The path of the connecting-rod big end is somewhat complicated, and does not lend itself readily to mathematical treatment. It may readily be plotted graphically, however, and will then be found to take the form indicated by the chain-dotted line in Fig. 2. The piston, as shown in this figure, is at the end of the firing stroke. The chief gain in efficiency resulting from the differential arrangement is obtained during this stroke, as its increased length with respect to the admission stroke enables a more complete expansion of the gases to be utilized than is possible in a normal engine. During the exhaust stroke the big end follows the outer curve of the longer loop of the path of the rod end to its highest point, and when this position is reached the piston is almost touching the cylinder head, with the result that the products of combustion are almost completely expelled. On the admission stroke the big end traces the inside of the shorter loop, and the cycle is completed by tracing the outside of this loop on the compression stroke. The compression ratio, as measured on the admission stroke, is 4.8 to 1, and during admission and compression the cycle is identical with that of an ordinary engine operating on the four-stroke cycle. (*Engineering*, vol. 124, no. 3226, No. 11, 1927, pp. 613–614, 4 figs., *d*)

IRON AND STEEL (See Fuels: Efficient Utilization of Fuel in Iron and Steel Works)

MACHINE PARTS

A Flexible-Gear-Tooth System

DESCRIPTION of the Wilkin flexible gear tooth form which has an extended addendum and a root with a radial dimension considerably greater than what is needed merely for clearance, Fig. 3. The working faces of the teeth are formed with the usual odontic curves, i.e., the teeth of mating gears can be either both involute curves or both cycloid curves. The addenda at their tips are relieved slightly from the theoretical in order to eliminate a sharp edge that would cut into the oil film on the approaching tooth. The result of such a design is that several teeth are in engagement at the same time. Further, the extension of the root is sufficient to make each tooth capable of a circumferential yield under load equal to the unavoidable departure from theoretical accuracy as to contour or spacing. At the same time the excess pressure required to produce this

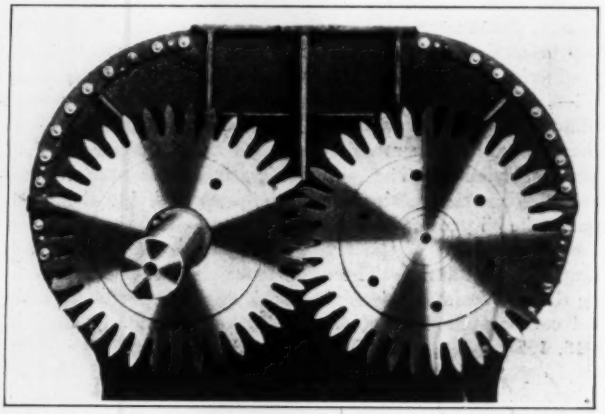


FIG. 3 WILKIN FLEXIBLE-TOOTH GEARS AS APPLIED TO A CONNERSVILLE BLOWER

yield is not sufficient to break contact completely between the adjacent contracting teeth.

It will be observed that the mass of metal near the top of the tooth is very small. Hence any shock due to mass resistance at the time of intial contact will be slight. This virtual elimination of mass resistance, combined with the flexibility of the teeth, will allow initial contact to occur without noise and without shock to the bodies of the gears. Furthermore, with a multiple number of teeth in contact and a resultant decreased intensity of pressure on the several teeth in contact, and because of the

absence of shock and hammering, better lubrication is accomplished and the life of gears is prolonged.

Fig. 3 shows a practical application of gears having this flexible tooth form, to a Connersville lobe-type rotary pressure blower. The face of the gears is 11 in. The contacting faces of the teeth are of epicycloidal form. An analysis of a pair of gears having this form of teeth shows their breaking strength to be greater than that of a pair of standard 14½-deg. involute gears of the same dimensions and number of teeth. [John T. Wilkin (Mem. A.S.M.E.), President of the Connersville Blower Co., Connersville, Ind. in *American Machinist*, vol. 67, no. 21, Nov. 24, 1927, pp. 809–810, 3 figs., *d*]

MACHINE TOOLS

A Center-Driven Wheel Lathe with Pneumatic and Electric Attachments

THIS lathe is intended for turning and profiling a pair of railway wheels mounted on their axle independently of the character or material of the wheels. It is built by Craven Bros., Ltd., of Reddish, Manchester. Compressed air is used

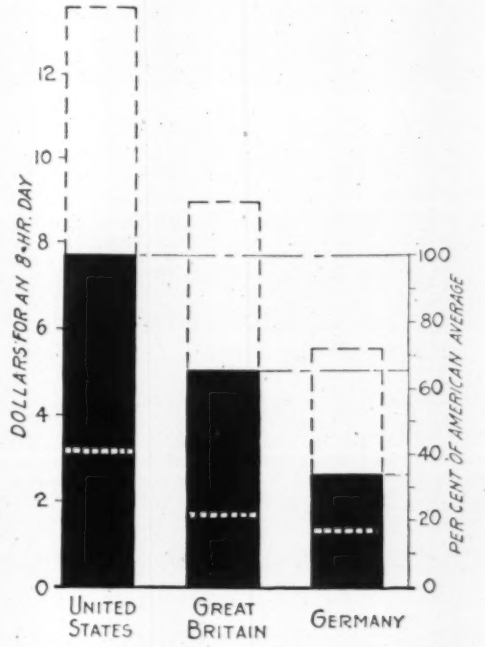


FIG. 4 AVERAGE WAGES IN THREE COUNTRIES IN THE IRON AND STEEL INDUSTRY

for clamping the tools and traversing and clamping the loose headstocks.

The following two features deserve particular notice. The spindle is slotted to permit of loading the wheels, and the main driving gear is fitted with a loose segment. This is opened when loading, and as the wheels enter the machine the axle strokes a lever on the side of the driving gear. Contact with this lever releases a balance weight and permits a swinging segment automatically to close the gap in the gear and lock itself ready for running.

The loose headstocks are quickly adjusted along the bed by means of a pneumatic cylinder and ram in the base of each headstock. When set they are clamped with equal facility by pneumatically operated clamps arranged on each side, as clearly shown by the two main illustrations of the original article. These consist of a substantial steel bar, which is supported at one end on a clamping pad and carries a clamping bolt that serves as a fulcrum when the bar is raised at the opposite end by a pneumatic cylinder and ram. As an alternative to pneumatic adjustment for the loose headstocks an electrically operated motion can be supplied, which is driven by a separate motor. [*Machinery* (London), vol. 31, no. 787, Nov. 10, 1927, pp. 172.2 figs., *d*]

MANAGEMENT

The United States Bureau of Labor Statistics

PUBLISHED data as to wages in the steel mills and subsidiary industries in the United States, Great Britain, and Germany. The average values for 1926 are shown in Fig. 4. Dotted lines represent the highest and lowest wages listed. A table of steel-mill wage rates accompanies the chart. The figures are such that it is not always possible to compare them for all three countries, and they do not always give the same picture. Thus, for example, the melters in the open-hearth furnaces receive for an 8-hr. day $9.36 in the United States, $2.17 to $2.74 in Germany, and $8.98 in Great Britain. Assorters in tin mills receive $3.04 in the United States and $4.89 in England. In the majority of cases, however, American rates are substantially higher than those in Great Britain and very much above those in Germany. For example, stokers in blast furnaces receive $3.76 in the United States and from $1.31 to 1.58 in Germany. Laborers in open-hearth furnaces receive $3.44 here and $1.64 in Great Britain. (*The Iron Age*, vol. 120, no. 21, Nov. 24, 1927, p. 1444, *g*)

MARINE ENGINEERING

The Application of High Pressures to the Reciprocating Marine Steam Engine

THE paper here abstracted deals primarily with the conversion of the machinery of the S.S. *North Borneo* from an ordinary triple-expansion installation working with superheated steam of 180 lb. pressure into a high-pressure one. This particular steamer is owned by the Netherlands Steam Navigation Co., and it is said that the decision to make the experiment originated in the somewhat uncomfortable feeling of uncertainty with regard to the future price of Diesel oil. The pressure selected was 500 lb., but reheating was rejected. As it was desired to make the installation as inexpensive as possible the existing engine on the ship was left and only the cylinders and valve gear were replaced by others suitable for the new conditions. Also, for the sake of cheapness it was decided to relieve the existing auxiliaries working with saturated steam of 180 lb. and drive them with steam tapped from the medium-pressure receiver. This arrangement was not expected to give the highest possible economy, but would considerably decrease expenses and still provide the desired information. Hawthorn-Armstrong water-tube boilers were selected, with furnaces to burn ordinary good coal. One of the advantages claimed for this boiler is that external cleaning is easy. This is done by steam jets and is facilitated by the fact that the tubes are placed in parallel rows and not zigzag.

Another feature of this boiler was considered especially favorable in this case as all sorts of coals had to be burned from the best British to the Ombilin coal from Sumatra, which latter is so volatile that only by special precautions is it possible to prevent a red-hot funnel and a huge flame on top of it. In this boiler the transmission of heat does not take place principally by radiation or principally by conduction, but both of these ways of transmission are equally active, hence the temperature of superheated steam is not too much affected by the differences in types of coal and in the quantities of steam passing through

the superheater nor by more or less forced stoking. The final design of the boiler is shown in the original paper. The steam temperature would here reach as high as 750 deg. fahr., and as it was not desired to raise the temperature of the flue gases to this point, the last portion of the superheater tubes was fitted as shown in the drawing referred to, otherwise it would have acted as a cooler instead of a heater. Also by this construction four drums could be used instead of seven. Priming may make it advisable for a fifth drum serving as a steam header.

The boiler mountings made of cast steel have given no trouble with the exception of the water gages. Bursting of the glasses occurs periodically, and besides this the glass becomes dull after a short period by the action of the high temperatures. Each boiler is therefore equipped with a Kelvin distance water gage. If kept tight to prevent leakages, this apparatus is said to indicate the water level very accurately.

In the engine, drop valves are used on all the cylinders. These are of the Meier Mattern type, the patent for which is owned by the Werkspoor Company. These valves are shown in some detail in Fig. 5.

Each cylinder has two inlet and two exhaust valves, all of the double-seat type, with the exception of the low-pressure exhaust valves, which have been built up of two sets of double-seat valves on a single spindle in order to insure sufficient opening without increasing the diameter, which is already $17^3/_4$ in.

The valves are pressed down in their seats by steam pressure, and opened by oil pressure by means of a piston fitted on the spindle. The spindles have also been provided with an oil buffer to prevent heavy hammering at the moment of shutting. The oil pressure is supplied by three pumps operated by three eccentrics on the crankshaft. Each of these pumps has two pistons on a single piston rod. As the motion of one inlet valve and also of one exhaust valve follows the motion of the other inlet and exhaust valves at an angle of 180 deg., the pistons may be double-acting, each side operating one valve. As, further, one inlet valve of a cylinder and the exhaust valve on the opposite side of the same cylinder should be open during the same stroke, the pump pistons for these two valves may have an identical motion, and for this reason they have been fitted on the same spindle. So each cylinder only requires one pump and one eccentric for its four valves.

When starting the engine there is no oil pressure available, and for this reason a small auxiliary pump is fitted, the oil delivered by this pump being distributed over the proper valves by means of small piston valves. Again, for the sake of keeping the expenses down, use has been made of the existing starting engine, no longer required for the link motion, to drive the starting pump. As soon as the main engine is in motion, the main pumps take over the duty from the starting pump, and this is stopped.

Reversing the main engine is done by turning a cock, by which operation the pressure pipes of the three pumps are interchanged. As is the case with an ordinary engine, a certain amount of lead is necessary, and when for a triple-expansion engine with three cranks under an angle of 120 deg. a lead angle of 30 deg. is chosen for the eccentrics driving the pumps, this matter becomes very simple indeed. Say the high-pressure eccentric has a lead angle of 30 deg., then if by interchanging the piping this pump will operate the low-pressure instead of the high-pressure cylinder, this eccentric will also have a lead angle of 30 deg. with relation to the low-pressure crank, but on the other side of the center and therefore in the proper position for running astern. The same applies to the other cylinders, so that the medium-pressure eccentric for ahead becomes high-pressure for astern and low-pressure becomes medium-pressure. Experimenting, it was found, however, that 30 deg. was not sufficient under all circumstances, contrary to what had been expected. This was mainly due to the fact that oil is not altogether incompressible, its compressibility being about three times that of water. The expansion of the pipes has so little effect in this matter that it may be neglected. For this reason it was found necessary to increase the lead angle of the medium-pressure eccentric a few degrees, but that of the low-pressure as much as 10 deg. to assure an adequate opening of the valves. For the ahead position this has no consequences, but for the astern position it means a corresponding decrease of this angle and therefore deformation of the diagram, which, however, was not of great importance.

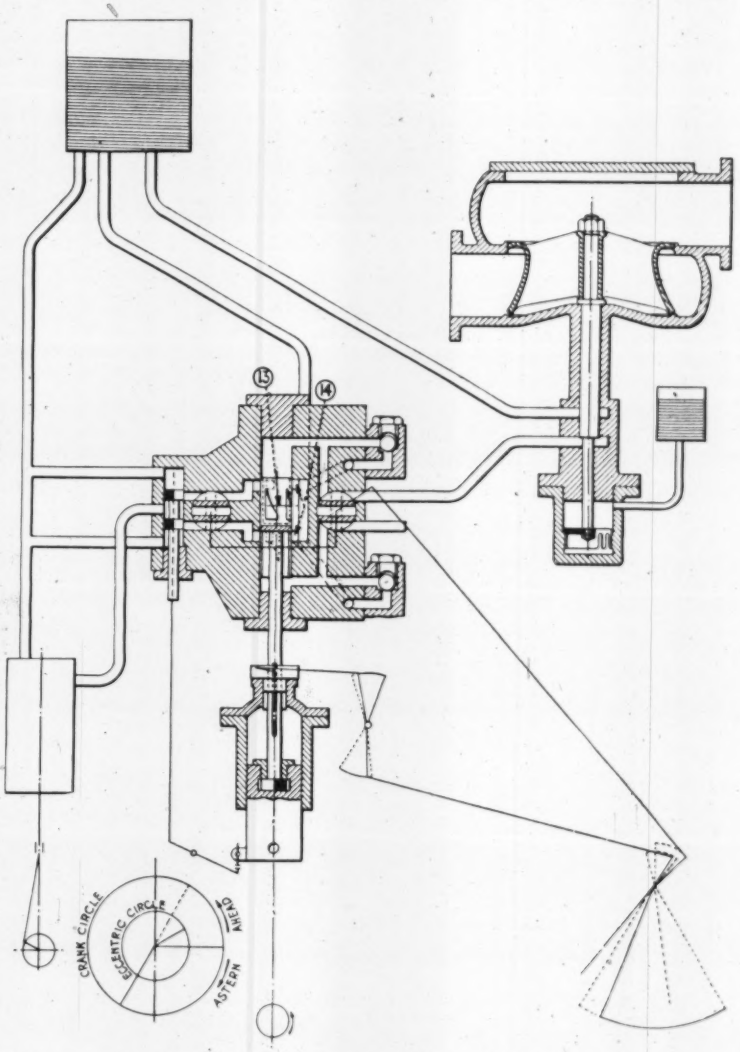


FIG. 5 THE MEIER MATTERN HYDRAULIC VALVE GEAR

The regulation of the admission of each cylinder is effected by turning the pump plungers. These are, as is shown in the sketch of Fig. 5, hollow, and provided with specially shaped holes 13 in

the circumference, communicating in a certain position with the holes 14. This position will present itself earlier or later when turning the plungers, and so the points of cut-off, release, etc. may be modified with one hand in one second. This arrangement operates in the same way as a Rider expansion valve, which used to be fitted to many engines for land work.

The advantages of the hydraulic over the mechanical gear are, among other things, as follows: The valves may be located immediately on the cylinder body; the regulation of the admission of each cylinder is independent of that of the others, so that for any desired power the best for each cylinder may be chosen, and this can be done by only a slight movement of a handle. Furthermore, not only may the valves be made large and heavy if required, but the heaviest valve may be opened almost instantaneously to its full lift and kept fully opened during a shorter period than is possible with the mechanically operated valve. This is shown by the valve-lift indicator cards in the original paper. The weight of one set of low-pressure exhaust valves fitted on one spindle is, including the weight of the spindle, 125 lb.

The lubrication of the high-pressure cylinder is mainly done by injecting water from the main feed pipe into the main steam pipe just before the stop valve, only a small quantity of oil being used as an extra safeguard. As a matter of fact, the engine was run without any oil at all. The explanation of this is that the water, broken up into small drops by passing the valve had no time to evaporate during the short period in the high-pressure cylinder but only evaporated in the medium-pressure receiver. An accurate examination of the indicator cards indeed showed a slight rise of the admission curve of the medium-pressure diagram when water was injected. This system of lubrication is only practicable, however, when a rotary feed pump or some other pump delivering a fairly constant flow of water is used. With an ordinary Simplex pump, for instance, it cannot be used because it would reduce the temperature by evaporation.

The author does not give any definite data as to the results obtained in actual service because these are not sufficiently available. He states, however, that it is well proved that a very considerable saving in coal consumption has been obtained by this conversion. The coal consumed was weighed with great care during the day in fair weather, so that the i.hp. could be kept practically constant, and it was found that the consumption worked out at 1.13 lb. of coal per i.hp. per hr. The heating value of this coal was 13,410 B.t.u. The figures received from the ship after completing her outward voyage confirm this, but it will be necessary to await the completion of at least three voyages to know exactly what the consumption will be in regular service, this being the smallest period in the author's company's trade in which a reliable judgment may be formed.

This result is very satisfactory, indeed, but it may be considerably surpassed by additional improvements of the installation. First of all, there is the feed pump that will actually be replaced by another; but a much more important saving may be obtained when the steam is worked off in the low pressure turbine instead of in a cylinder, because a turbine would in this case have a much higher thermal efficiency than a cylinder. It seems, indeed, that the combination of high-pressure cylinders and a low-pressure turbine for the whole plant throughout would show an efficiency that makes it possible for a coal-fired steam plant to compete with a Diesel motor, and, as was stated in the introduction, this is possible. In most cases a turbine built on the main shaft after the Bauer-Wach principle, with a hydraulic coupling between, would seem an acceptable means for finally proving this possibility of visible results. This should be the first step, the author thinks, after ample experience with the high-pressure steam installation itself is available and technical difficulties have been completely overcome.

It may be of interest to note the following minimum and maximum temperatures, observed during two periods of three days running, under the same circumstances, with the exception of the temperature of the air at inlet fan.

	Deg. Fahr.		Deg. Fahr.	
	min.	max.	min.	max.
Air at inlet fan	113	118	127	129
Air after heating	280	293	295	320
Combustion gases before heater	565	588	556	576
Combustion gases behind heater	460	482	462	473

Certain difficulties developed, but the majority of these are not important. The most serious trouble, in fact an accident, was the simultaneous bursting of four boiler tubes of one of the boilers. The boiler blew empty in a very short time, but as the fire was also immediately extinguished, no further harm was done. Inspection showed that the boiler had been short of water; all the tubes were more or less bent, and several had to be reexpanded before the boiler could be used again. This accident happened after one of the safety valves, which are fitted on both top drums, had been blowing hard for some time, and herein is most likely to be found the cause of the accident. The water-level regulators had not always done their duty so well as was desirable, and one boiler having more steam pressure than the other, it received less feedwater. In addition to this, only one of the safety valves blew, as very often is the case, and a considerable under-pressure must have been created under this valve by the velocity of the steam; for the four burst tubes were all situated under the valve. (S. G. Visker in a paper read before the *North-East Coast Institution of Engineers and Shipbuilders*, Nov. 17, 1927. Abstracted from advance print, 22 pp., illustrated, *dA*)

MOTOR-CAR ENGINEERING

The Spontan Transmission Gear

IN THIS new transmission gear designed by F. Ljungström of the Spontan Co., Stockholm, every operation necessary for the control of a car other than steering is performed by the movement of a single pedal.

The essential features of the gear are shown diagrammatically in Fig. 6. The wheel carrying three pins on which planet wheels are mounted may be assumed to be the flywheel of the engine. The sun wheel is attached to the transmission shaft and an unbalanced weight is attached to each planet wheel. If it be assumed that the resistance of the transmission shaft is exactly equal to the engine torque, the whole of the elements will rotate together as a solid body without any rotation of the planet wheels about their own axes. This condition corresponds to the normal direct drive on a car. If now it be assumed that the resistance to rotation of the inner shaft increases, as would be the case if the car commenced to ascend a hill, the flywheel on the same throttle opening will tend to rotate faster than the transmission shaft. Such a motion involves the revolution of the planet wheels about their own axes, the rate of revolution depending upon the required difference in speed between the driving and the driven shafts

FIG. 6 DIAGRAMMATIC ILLUSTRATION OF THE OPERATING PRINCIPLE OF THE SPONTAN TRANSMISSION GEAR

The actual difference is established by the relation that, frictional losses being neglected, the torque multiplied by the angular velocity must be the same on the two sides. When the planet wheels commence to revolve, the balance weights will be carried toward the common center, a movement which is opposed by the centrifugal force on the weights during half a revolution and assisted by the same force during the second half. In their inward motion, therefore, the weights must be absorbing energy from the engine, this energy being given out on their outward motion. Since the turning moment on the sun wheel will be alternately positive and negative according to whether the weights are moving outward or inward, means must be provided to transmit the drive to the propeller shaft during the incidence of the positive moment and to afford an anchorage to a non-rotative element such as the casing of the gear box during the incidence of the negative moment.

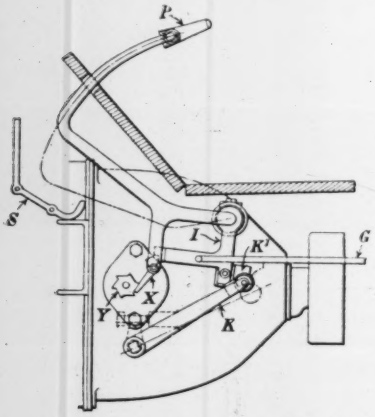


Fig. 7 Actual Arrangement of Controls in the Spontan Transmission Gear

In actual construction a movement has been evolved by which these fluctuating impulses are transferred to the propeller shaft. The details are shown in the original article. The sun and planet wheels are replaced by a system of eccentrics, a sleeve concentric with the propeller shaft carrying three eccentrics with their weights mounted about the disks by means of ball-bearing rings. These weights are connected to the flywheels of the engine by pivoted links. The second flywheel is mounted on the driven shaft.

Two inner sleeves are provided, one of them coupled to the driven shaft and the other connected to the second flywheel, and between the outer and each inner sleeve there is a set of rollers, the inner sleeves being provided with inclined surfaces in such a way that they will form a mechanical valve or one-way clutch.

From the diagrams shown in the original article it would appear that when the engine is driving the propeller shaft only the torque actually produced by the engine can be directly transmitted to the shaft. The actual arrangement of the controls is shown in Fig. 7. The cranked lever I is keyed to the same shaft as the pedal, and therefore always moves with it. It is fitted with a block K^1, with a recess in which a roller on the end of the lever K engages. The latter lever is mounted on the end of a long circular rod rigidly held at the opposite end, and serving the purpose of a brake spring. The brake rod G is coupled to the lever I, and, in the position shown, the brakes are full on. To release them, the pedal is depressed, forcing the roller on the lever K out of the recess, the face on the head of the lever I being so formed that, as the pedal is further depressed, the resistance offered by the torsion rod, to which the lever K is attached, gradually becomes less. At a certain point the pedal reaches the throttle lever S, and, in this position the resistance transmitted to the pedal by the torsion rod is very slight. Further movement of the pedal opens the throttle to any desired extent, and thus governs the speed of the car. To slow the car down, the pedal is allowed to rise, first closing the throttle, then passing through the free-wheeling position and finally applying the brakes.

To reverse the car it is necessary to pull the lever back from the position shown in the figure, and a stirrup P, which fits over the foot, is provided on the pedal for this purpose. The act of raising the pedal causes a spring-loaded pawl X to engage with the ratchet wheel Y. The latter wheel is mounted on the end of the reversing shaft in the gear box, and when the pedal is again depressed, this shaft is turned and actuates the gear-box sleeve, reversing the gear as already explained. On completion of the reverse movement the pedal is again pulled by the stirrup, and again depressed. This has the effect of turning the reversing shaft further, and restoring the sleeve to the forward position.

The author states that he had an opportunity of testing the Fiat car to which the gear had been fitted, and found the designer's claim regarding the simplicity of control fully substantiated. The inventor of the gear is the brother of Birger Ljungström, the designer of the Ljungström turbine. (*Engineering*, vol. 124, no. 3227, Nov. 18, 1927, pp. 658-661, 20 figs., *d*)

POWER-PLANT ENGINEERING (See also Steam Engineering: The Erosion of Turbine Blading)

A New Form of Water-Tube Boiler

OTHER things being equal, that boiler which brings the maximum amount of tube surface into contact with the greatest amount of radiant heat will be the most efficient and the cheapest. The heat transmission in a tube by convection is, however, affected by the film of relatively cool gas which clings to the surface of the tube. J. G. Hudson found by experiment that of the temperature drop between the hot gases and the water of a boiler about 98 per cent is spent in forcing the heat through the dead-gas film, and Professor Dalby considers that 97 per cent is required to overcome the resistance of the gas film, 1 per cent to overcome that of the plate, and 2 per cent that of the water film. However, if the hot gases could be directed downward, then the support afforded to the dead film causing it to remain attached to the tube would be done away with. The proper way to insure complete transference of heat is for every tube to function fully as a steam evaporator, and for this the gases should progress along the tube in the opposite direction to the water circulating in it. Today in most boilers both gases and water flow in the same direction.

A new type of boiler called the "Rational" has recently been developed in London and is said to embody the principles presented above. It also employs a method of firing pulverized coal by means of which the coal is distributed in parallel ribbons. This is said to result in complete and rapid combustion. An illustration in the original article shows a Rational boiler designed to generate 30,000 lb. of steam per hr. The coal and air pass down through a special form of burner which produces a number of fine ribbons of coal and air that extend the whole width of the boiler setting. Secondary preheated air from an air heater is admitted at high velocity around both sides of the burners and deflected across the parallel ribbons of coal and air from either side, the admixture dispersing through an aperture $1^1/_2$ in. wide at a speed of about 25 ft. per sec. into the refractory burning chambers.

The ascensional hot gases exert a slight pressure upward, and this contributes toward rapid and complete combustion because the light hydrocarbons do not have any opportunity of slipping away without being burnt. This is a matter which presents many complexities in methods of firing at present in use.

As soon as the gases leave the refractory burning zone at about 18 ft. per sec., there is a slowing up of their descent to about 8 ft. per sec., and this generally decreases to, say, 4 ft. per sec. at the lower end of the steam-raising tubes. In ordinary water-

tube boilers when once carbon particles or unburned gases reach the congested and staggered-tube zone, further combustion is impossible. In the case of the Rational boiler there are wide passages between the sets of tubes, viz., 1 ft. $5^1/_2$ in., and therefore any carbon particles which escape from the refractory burning zone must continue the process of burning during their descent. (*Combustion*, vol. 17, no. 5, Nov., 1927, pp. 297–299, 2 figs., *d*)

A Submerged-Combustion Boiler

THIS type of boiler is also known as the internal-combustion boiler. One such design by Brunler was described in MECHANICAL ENGINEERING, vol. 47, no. 5, May, 1925, p.

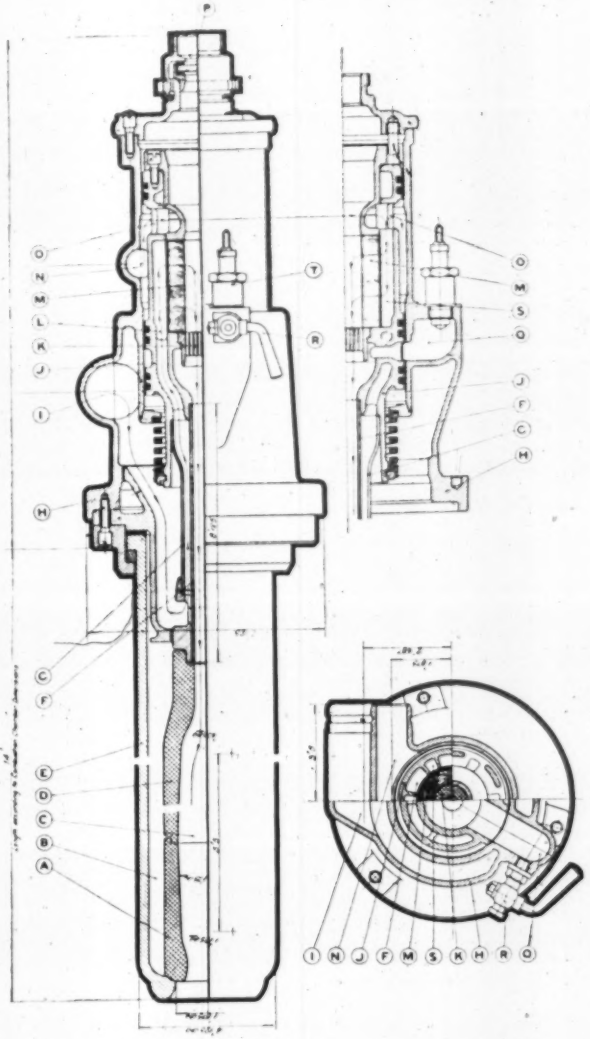


FIG. 8 THE HAMMOND SUBMERGED-COMBUSTION BOILER

(*A*, refractory lining; *B*, packing cavity; *C*, combustion chamber; *D*, refractory lining; *E*, outer casing; *F*, high-velocity tube; *G*, air-transfer tube; *H*, main body; *I*, air inlet; *J*, mixing chamber; *K*, Méker grid; *L*, air port; *M*, mixing pack; *N*, gas inlet; *O*, chamber ports; *P*, flame sight; *Q*, ignition chamber; *R*, gas vent cock; *S*, gas duct; *T*, sparking plug.)

358. The other type is the Hammond boiler (Fig. 8). In this it is claimed that provision is made for meeting all the requirements of perfect combustion under conditions of submergence, while deterioration of the burner in use is prevented. The refractory lining forming the combustion chamber is mounted so as to accommodate differences in expansion between it and the outer casing, thus avoiding stresses on the refractories. It is separated from the casing by a chamber in which packing material is introduced to act as a conductor variable in its nature according to the conditions of operation and the rate of heat generation. The air for combustion entering at a port *j* circulates round the body of the high-velocity tube *f*, as shown by the arrow line, and passes through the mixing pack *m*, where it is intimately mixed with the incoming fuel from port *n*, by means of fine jets of gas and air impinging on each other. The mixture then passes through the high-velocity tube into the combustion chamber at a speed which prevents the backward propagation of flame, thus insuring combustion only in the proper chamber. A sparking plug in an auxiliary ignition chamber provides for initial ignition or lighting up, the fuel-air mixture for purposes of ignition being fed through a bypass. After ignition has been effected, the flame is carried through the high-velocity tube to the combustion chamber by turning on the main proportioning valve to give the minimum supply of air and fuel, after which combustion is confined to the combustion chamber proper. This unit not only secures perfect combustion, but also resists the destructive effects that have hampered the earlier designs; units of the type shown have been in full-duty operation for over 2000 working hours without any deterioration.

Submerged combustion apparently finds its best industrial application in chemical work such as the evaporation or concentration of chemical solutions. Here the ease with which a steady circulation in the solution can be maintained is important in avoiding local heating and incrustation of the container. The present article describes a Hammond circulatory unit, which is claimed to create an effective circulation and in addition avoids passing the products of combustion through the main body of the fluid. In another form of the Hammond apparatus a lead or similar metal bath is interposed between the flame and the product to be heated. By this means it is possible to employ submerged combustion for treating sodium hydroxide or caustic soda solutions without the products of combustion coming into contact with the material. The medium in which the flame operates comprises a lead bath in a container in which the combustion chamber is immersed, surrounded by a casing to produce an air-lift circulatory effect. The caustic soda or any other material to be treated is contained in a spiral chamber floating on the surface of the molten lead and thereby being heated to the temperature of the latter. A modified design has been provided for use where the treated metal is required to be heated under pressure. (Third installment of a serial article entitled, "The Development of Submerged Combustion," in *Oil Engineering and Technology*, vol. 8, no. 10, new series, Oct., 1927, pp. 371–373, illustr., *d*)

Eighty Per Cent Boiler Efficiency with Low Plant Factor

THE steam plant operating in connection with the water plants of the Northern States Power Co. at times carries only the peak loads, thus operating very light, and then on very slight notice may have to carry the base load. Formerly it was the practice to operate as many boilers at high ratings as were needed to carry the station load and have available additional boilers under "dead banked" conditions to take care of emergencies. During the light-load periods, therefore, the average boiler efficiency, and consequently the plant thermal efficiency, was considerably lower than during heavy-load periods. Such banking of boilers involved a large additional expense and experiments were undertaken at the company's Riverside station, Minneapolis, to determine the possibility of operating boilers under light-load conditions with an efficiency approximating that obtained at high rating. The tests were made on a Babcock &

Wilcox boiler of the cross-drum type equipped with a superheater of the convection type, and on a different boiler of the same capacity but having a slightly larger superheater and a larger furnace. The results of the preliminary tests are given in a table. These tests were made by operating the boiler for periods of two or three days with the stack damper entirely closed and the stoker operating intermittently for periods of 15, 10, and 5 min. in each hour. Next, a weighed-coal efficiency test of 76 hr. duration was run at 35 per cent of rating. This run gave an efficiency of 79.5 per cent with 10 per cent carbon dioxide, a stack loss of 10.8 per cent, and a carbon-in-refuse loss of 0.8 per cent. This test was run on the Babcock & Wilcox boiler. A second test on a different boiler gave 76.4 per cent efficiency at 50 per cent of rating with 9.4 per cent CO_2. The higher percentage of rating in this case was due to a greater draft and to the fact that it was necessary to operate the boiler at relatively high percentages of rating for a period of two to three hours each day to improve the fire. The lower efficiency in this test is accounted for by a stack loss of 12.2 per cent and a carbon-in-refuse loss of 2.4 per cent. These higher losses were due to a relatively uneven fuel bed.

These tests were so satisfactory that it was decided to commence operating regularly under similar conditions. Results obtained at Riverside station in 1922 and 1924 on the old basis of "dead banking" and those obtained at the same station in 1926 with low-rating operation offer a striking comparison. During four months in the years 1922 and 1924, when the average monthly plant factor at this station was only 6.2 per cent, the average monthly boiler-room efficiency was 68.2 per cent. During six months of 1926, under the new method of operation, when water-power conditions were good and the average monthly plant factor at Riverside station was only 5.5 per cent, the boiler efficiency averaged 80 per cent. It is estimated that at least two-thirds of this increased boiler efficiency is attributable to the new method of operation. The same method of operation was also adopted at the High Bridge plant in St. Paul, with the result that monthly boiler efficiencies of more than 78 per cent have been obtained on a plant factor of only 5 per cent. (Lawrence Washington and H. W. Meyer in *Electrical World*, vol. 90, no. 19, Nov. 5, 1927, pp. 940–941, 1 fig., *dp*)

Small Steam Turbines

TURBINES are usually classed as small when the horsepower developed does not exceed 750, but in comparison with turbines developing 250,000 hp. it might be good practice to regard turbines of 2500 to 3000 hp. as small. The author describes the various existing types of these turbines with brief historical references. Notwithstanding the growing employment of electrically driven auxiliaries in central stations, with regenerative feed heating by steam bled from the main turbines, and air preheaters used instead of economizers, small turbines have been so improved that they hold their own, and, indeed, offer certain advantages to the designer and operator.

The essential auxiliaries at East River, the new station of the New York Edison Company, are all steam driven, as well as certain of the non-essentials which have a duplex drive. In the investigation which led to this decision it was found that the heat economy of all three systems was sensibly the same, within one-quarter of one per cent. Reliability was perhaps a little better for the steam auxiliary system, since only one link—the steam piping—must be safeguarded instead of two, as with the electric systems. The first cost was also greatly in favor of the steam system when the electrical systems were properly safeguarded.

Many of the turbines are built for condensing use and many are geared, thus taking advantage of the best known ways for attaining thermal economy. Some of the best machines have many stages and in design are really small turbines; that is, large turbines built down in size, as many as 40 stages being used.

One of the machines, made by Tosi in Italy, is of 500 hp., and of the Parsons type, and gave an economy on the test blocks, condensing under 200 lb. pressure, of about 11 lb. of steam per hp. The Brown-Boveri Company has machines of this type also with about the same water rate. Loesel machines with 40 stages have also been built, but information is wanting as to water rates.

Taking all things into consideration, the small steam turbine is a most advantageous piece of apparatus. It is light and occupies a very small space. It is rugged in construction and automatic in operation. It is economical in the use of steam in proportion to the price paid for it. It has no depreciation nor serious repairs, requires little attention, uses little oil, and maintains its economies over a series of years. Characteristics of small turbines, condensing and non-condensing, and other information are given in the form of curves in the original article.

In the discussion which followed the author pointed out that where labor is cheap it is possible to build a more complicated machine that will get better efficiency. By spending time on polishing, a much better machine may be had. One time Mr. West of the E. P. Allis Co. told the author how he had spent a week polishing up the piston heads of a pumping engine, and when he ran the test he got an extra quarter-pound on the water rate. Those things can be done, but a good turbine designer knows his shop and designs the kind of machine he can build in his shop with his tools and his men at the cheapest rate, to sell for the most money. There is no reason why any one turbine designer cannot duplicate the water rate of another turbine designer.

In comparing the efficiency of European and American stations, the author pointed out that there are two stations in the whole of Europe that are doing better than 20,000 B.t.u. per kw-hr., while there are 35 stations of various sizes in the United States that are doing better than that. [Geo. A. Orrok (Mem. A.S.M.E.) in a paper presented at Conference on Auxiliaries of the Boiler Plant, Dec. 16, 1926; abstracted through *Proceedings of the Engineers' Society of Western Pennsylvania*, vol. 43, no. 6, July, 1927; original paper pp. 269–273, 4 figs., and discussion pp. 273–278, *dp*]

PRODUCER GAS AND GAS PRODUCERS

A Combined Gas Producer and Lime Kiln

DESCRIPTION of an installation of a small lighting plant at Spring Bank Mills, Hearthfield, Sussex, England, based on information supplied by Prof. A. M. Low. The plant consists of a gas engine of 37-40 b.hp. driving a 25-kw. dynamo, but the ordinary gas producer is replaced by a lime-burning kiln, which in addition to making lime acts as a gas producer. The process of manufacturing gas fuel from lime-kiln gases is the invention of Dr. T. A. Reid, F.C.S. The unit is not a large one, the kiln being only 3 ft. 6 in. in diameter and 8 ft. high. It consists of a steel casing with a firebrick lining extending rather more than three-quarters of the way down, while through the center of the casing is carried a transverse iron retort. The top of the casing forms the firing platform on which is situated the charging hopper.

A mixture of coke and limestone in the proportion of 280 lb. of coke to one ton (2240 lb.) of limestone is introduced into the kiln through the charging hopper, and lime is produced from the limestone by the liberation of carbon dioxide. The only outlet for the gas is through the retort, the bottom of which is perforated, and the retort contains coke or anthracite maintained at red heat by the combustion of the fuel in the body of the kiln. This reduces the carbon dioxide to carbon monoxide. This

gas is diluted by the nitrogen content in the air of combustion, and the resultant gas contains 25 to 30 per cent of carbon monoxide and burns quite effectively either in a gas engine or under a steam boiler. Instead of coke or anthracite, bituminous coal may be used; this latter enriches the gas by the addition of hydrocarbons. As a matter of fact, this is probably the best way of firing the kiln, and chalk may be used instead of limestone.

Some of the mechanical details of operations are given in the original article. The plant at present installed is experimental only in the sense that it is on a somewhat small scale. In a larger plant a vertical firebrick chamber will be substituted for the horizontal cast-iron retort. (*Gas and Oil Power*, vol. 23, no. 266, Nov. 3, 1927, pp. 21–22, 1 fig., *d*)

PUMPS

Control of Centrifugal-Pump Output and Characteristics

THE article here considered deals with centrifugal pumps and shows that while power is saved by throttling the suction of a pump rather than the discharge, cavitation and unstable operation may result. In the majority of cases, particularly where centrifugal pumps are directly connected to induction motors, a change in pump speed cannot be made. Other means must therefore be found to reduce the quantity pumped. Pump manufacturers usually recommend not to throttle on the suction side. Such a procedure may cause the pump to lose its prime, particularly where there is leakage around the stuffing glands or where it is necessary to throttle the pump over a large range. Throttling on the suction side may also produce cavitation, and consequent pitting of the runner. Cavitation in this case means that the vacuum within the runner is so high and so nearly approaching the maximum possible that there is not available sufficient head or pressure at the entrance of the runner to force the water into the runner as fast as it is needed to fill up the vanes. As a result there is a separation of the water from the runner. More water comes in after an instant and the process repeats itself, producing all the while a noise.

On the other hand, the loss or waste by throttling on the suction side is limited to a theoretical maximum of 34 ft., while on the discharge side an artificial head can be built up much higher than the original head against which the pump was operating when the discharge valve was wide open. This is essentially why it is frequently possible to save power by throttling on the suction side of a centrifugal pump. The author shows by curves how power input may be decreased with throttling on the intake side, even though the efficiency is lower than with the discharge throttle. The curve cited also answers the question whether it will injure a centrifugal pump to close the valve on the discharge side. If the valve is completely closed the quantity will then be zero and the pump will require the minimum amount of power to operate it, but if the pump is left to operate under such conditions for a period of time, it may lose its prime and may be badly overheated. The case of the two-stage pump, its characteristics, and the location of valves is next discussed. (Blake R. Vanleer, Assistant Professor of Mechanical Engineering, University of California, in *Power Plant Engineering*, vol. 31, no. 21, Nov. 1, 1927, pp. 1133–1134, 2 figs., *gp*)

REFRIGERATION

The Effect of Compressor Speed upon Refrigerating Capacity and Efficiency of Household Machines

THE paper here abstracted is based on tests carried out on a compressor operating at a speed of about 330 r.p.m. on standard installation. The capacity and efficiency of the compressor had been determined at speeds of 220 to 680 r.p.m. It should be noted, however, that even though the capacity and efficiency of the compressor may be greater at high speeds, these are not the only considerations to be taken into account when designing the compressor, wear and quietness being also problems of great importance.

The authors describe in detail the testing apparatus used and present the data of the tests in the form of a table and a series of curves.

Among the results obtained the following may be mentioned. Power consumption was found to be practically a linear function of the compressor speed. The total power-consumption–compressor-speed relationship, however, deviates very slightly from a straight line at lower compressor speeds. The fact that the power consumption of the compressor is approximately a linear function of the speed would seem to indicate that the lubrication of this compressor is very good and that the surfaces were separated by a fluid film. The theory of complete fluid-film lubrication requires the frictional losses to be a linear function of speed and independent of bearing pressure. The relation between compressor speed and friction loss appears to be in accord with this theory. The compression efficiency appears to increase with compressor speed, while the mechanical efficiency decreases with compressor speed. The product of these two efficiencies, which is the overall efficiency of the compressor, increases slightly with speed, which is due to the fact that the compression efficiency increases faster with the compressor speed than the rate of decrease of the mechanical efficiency with speed. Since the compression efficiency is based upon adiabatic compression, an increase in compression efficiency is to be expected at higher speed where the actual compression is more nearly adiabatic. This increase in compression efficiency with speed also indicates that the valves functioned as well at a speed close to 700 r.p.m. as they did at 200 r.p.m. The suction temperature was nearly constant during the test except at the higher speeds, where it was slightly lower. The discharge temperature increased with the compressor speed. This is to be expected since the friction losses are greater at higher speeds. The general conclusion of the test is that it might be possible to build a higher-speed compressor of smaller bore and stroke and lower manufacturing costs with an ultimate gain in efficiency, but that this would entail greater wear and more heating. The latter, however, might be overcome by using more effective lubrication. [No. 4 of a series of papers on household refrigeration, reporting work done at the University of Michigan and sponsored by the Kelvinator interests. C. C. Spreen (Mem. A.S.M.E.), Detroit, Mich., and L. A. Philipp, Ann Arbor, Mich., in *Refrigerating Engineering*, vol. 14, no. 5, Nov., 1927, pp. 145–149, 4 figs., *ep*]

STEAM ENGINEERING (See also Marine Engineering: The Application of High Pressures to the Reciprocating Marine Steam Engine)

The Erosion of Turbine Blading

THE evidence now available seems to show that in general it is the water suspended in the steam that causes erosion of turbine blading. It would therefore occur primarily in the parts of the turbine beyond the stage where condensation begins to take place.

Whatever view may be taken as to the extent to which supersaturation persists in the low-pressure section of a turbine, there is a general agreement that condensation does not occur immediately the saturation line is crossed, but is delayed until the steam is very considerably undercooled. There is then a sudden condensation, some 3 per cent of the steam (possibly much more) being practically instantaneously deposited in the form of drop-

lets. Hence at this one stage there is a very large amount of water uniformly suspended in the steam. This is subsequently flung out by the centrifugal forces developed when the steam flows through a moving row of blades, and thus passes subsequently mainly through the clearance spaces rather than through the blading. It is true, of course, that further condensation occurs as the expansion of the steam is carried further, but it seems probable that never again is there so instantaneous, so copious, and so uniform a condensation of moisture as occurs on the first crossing of the Wilson line. The subsequent progressive condensation is progressively expelled to the casing walls and makes its way down the turbine as best it can. It is probably this concentration of the moisture by centrifugal forces into the clearance spaces which is responsible for the very high estimate at one time made as to the loss due to tip clearance in reaction turbines. Owing to centrifugal action, the fluid passing through the outer clearance spaces contains far more than its due proportion of moisture; and the weight thus traversing the clearance, and doing accordingly little or no useful work, may thus be much greater than purely geometrical considerations would indicate. With superheated steam, on the other hand, it is mechanically and physically impossible that the loss by tip clearance in the axial-flow type of turbine should be proportionately more than the percentage of the steam way through the clearance to the total steam way provided.

The development of the very high local pressures required to produce erosion is due to the fact that water is a viscous liquid. If a drop is flung against a solid wall it strikes in the first instance at a point. It may be said with very rough approximation that the liquid along a little central cylinder having this point as base is brought to rest by a wave of compression which traverses it with the speed of sound. The layer of liquid surrounding this little cylinder carries on for a little longer, and in the meantime there is accordingly a very great difference in the velocity of the little central cylinder and that of the fluid immediately surrounding it. A shearing force is thus developed between the two which is proportional to the coefficient of viscosity μ multiplied by the rate at which the axial velocity of the fluid changes as one passes outward radially from the central cylinder. The rate of change of velocity may be represented by dv/dr, and the shearing force on the surface of the little inner elementary cylinder will thus be proportional to $\mu dv/dr$. It may therefore be very large even when μ is very small. The viscosity of the fluid therefore makes the little drop act almost as if it were solid, and the pressure at the point of impact is very much greater than it would be were the metal attacked by a solid jet of water moving with the same velocity as the droplet.

In reaction turbines of the ordinary type, the erosion appears to be confined to the moving blades, which, as Dr. von Freudenreich has suggested, would seem to be due to the fact that the moving blades fling out to the wall of the casing any moisture which separates out while the steam expands through them. By an ingenious course of reasoning he has, moreover, been able to deduce the probable average velocity of the water droplets, and finds it to be very much less than that of the steam. He suggests that the relatively low efficiency of turbines operating with wet steam may originate here, and shows that curves calculated on this assumption agree in form, if not in absolute value, with standard correction curves.

It may be noted in passing that with axial-flow reaction turbines the efficiency depends to some extent on the axial spacing of the blades. Close crowding of the rows results in some loss of efficiency, but even an apparently excessive axial spacing has little or no detrimental effect. With very close spacings, moreover, the trailing edges of the blades have, in certain cases, been eroded, apparently due to the effect of splash from the inlet edges of the succeeding row. (Editorial in *Engineering*, vol. 124, no. 3227, Nov. 18, 1927, pp. 651–652, *ta*)

THERMODYNAMICS

The Mechanical Equivalent of Heat

SINCE Joule there have been only two important direct determinations of the mechanical equivalent of heat, one of the fundamental constants of physics. Both determinations are said to be open to criticism in the light of modern standards of accuracy—Rowland's on account of his thermometry, and Reynolds and Moorby's because the heat losses were uncertain and the steadiness of conditions essential to continued-flow calorimetry was not realized.

The present investigation, when extended over a considerable period of time, was carried out by the continuous-flow method of calorimetry, using an induction dynamometer differing only in some particulars from that described previously by Dr. Roberts, who, with Dr. T. H. Laby, senior author of the paper here abstracted, began experiments upon the mechanical equivalent of heat in 1918. The rise of temperature of the water was determined by platinum thermometers connected differentially, and the most painstaking effort was made to reduce variations in the rate of flow as a source of temperature variations.

A direct determination of the mechanical equivalent of heat made by the authors gives the value 1 calorie at 16.7 deg. cent. $= 4.1841 \times 10^7$ ergs, which is equivalent to 1 cal. at 15 deg. $= 4.1860 \times 10^7$ ergs and 1 cal. at 20 deg. $= 4.1809 \times 10^7$ ergs. This value agrees with values found by indirect electrical experiments and so confirms the present accepted absolute values of the practical electrical units. (T. H. Laby, Professor of Natural Philosophy, and E. O. Hereus, Lecturer in Natural Philosophy, University of Melbourne, in *Philosophical Transactions of the Royal Society of London, Series A*, vol. 227, 1927, pp. 63-91, 8 figs., *eA*)

The Transfer of Heat in Cylinder Walls

AN ABSTRACT of the first of a series of lectures under this title arranged by the University of London, appeared in MECHANICAL ENGINEERING, vol. 49, no. 12, December, 1927, p. 1357. In the second lecture, here abstracted, Professor Nagel further referred to the work of other engineers on this subject which is today, however, of only historical importance. Of more practical interest is the work of Heinrich on condensation of steam on the cylinder walls during admission and method of calculating the heat-interchange equation by taking into account the temperature difference between steam and wal and the surface area at any time with different points of cut-off.

Prof. W. Nusselt of Munich tried to explain the heat transfer between steam and walls by assuming that a film of moisture is formed on the wall, the temperature drop from steam to wall taking place through the thickness of the film. Thus, owing to the heat conducted through the film from the steam to the wall, steam will condense, at the temperature corresponding to the saturation pressure, on the outside of the film. The condensate built up runs away under gravity and leaves behind a film whose thickness, constant at any point, depends on the viscosity of the water, the form and inclination of the surface, and so on. In applying this theory to condensation taking place during admission in an actual engine, the flowing away of the condensate under gravity may be neglected since the available time is too short for the effect to be measurable. Nusselt's original formula with this modification gives a very simple expression for the coefficient of heat transfer, viz., $\alpha = \lambda/y$, where λ is the coefficient of thermal conductivity of the water and y the momentary thickness of the film of moisture. Assuming that at the point of

admission the wall is dry, i.e., $y = 0$, and that at cut-off the film thickness is y_1, then the mean film thickness may be taken as $y_m = y_1/2$. In the Heinrich tests described, $y_1 = 0.0284$ mm. If the value $\lambda = 0.705$ kg. cal. per sq. meter per deg. cent. through a thickness of 1.0 mm. per hr., determined by Professor Jakob, of Berlin, at a temperature of 160 deg. cent. be taken, the mean value of $\alpha = \frac{\lambda}{y_m \times 10^{-3}} = \frac{0.703}{0.0142 \times 10^{-3}} = 50{,}000$, which agrees closely with the value found by other methods. In this, λ is a constant, while y increases from 0 to y_1, hence it follows that α is decreasing during admission, and that the above is a mean value for the whole admission period. Nusselt derived another relationship from this speculation, that of the dryness fraction at the point of cut-off. This he found to depend upon the speed of running and upon the point of cut-off. A table for the values of α obtained by various investigators is given in the unabridged lecture.

The next subject is the question of heat transfer in internal-combustion engines. Here again the Nusselt tests are of practical and still timely interest. In order to separate the heat received by the wall by radiation Nusselt made experimental use of the facts that this heat varies as the cube of the linear dimension of the containing vessel, while that received by conduction varies as the square of the linear dimension. He therefore carried out similar tests with hollow vessels of different sizes, but geometrically similar. The diameters of these spherical vessels were 200 mm., 400 mm., and 600 mm. (7.87, 15.74, and 23.62 in.), respectively, the intermediate size being intended to act as a check. A further variation of conditions was obtained by gilding and polishing the interior of the vessels in one series and by blackening over the gilding in a second series.

Calculations made from the first series brought disappointment and really led to a change from the original plans. In the case of the gilded inner wall the radiation is, for the most part, reflected until it is absorbed by the gas charge. The results, therefore, when the gas charge was allowed to cool in the gilded vessel, should depend almost entirely upon the conduction of the heat. Contrary to expectation, a surprisingly large decrease of the coefficient of heat transfer resulted at the beginning of cooling, i.e., after maximum temperature. Nusselt, in attempting to clear up this phenomenon, discovered that the cooling of a hot gas charge enclosed in a cold metal vessel first takes place in accordance with the facts that in addition to the instantaneous temperature, composition, and density of the gas, the time interval from the beginning of cooling is also important. The smaller this interval the larger the coefficient of heat transfer.

This influence of time follows from the fact that the sudden contact of the hot gas charge with the cold wall modifies the temperature gradient in the charge, from outside toward the inside, as a result of the heat delivered to the wall. This influence is further increased, since the heat conduction within the gas after a certain interval produces a new temperature gradient. After this the coefficient of heat transfer is no longer dependent upon the time. Nusselt therefore stated that the coefficient consists of two parts: one part, under constant density conditions, depending only on the temperature; the other, only on the time and called by him the "time factor." Unfortunately, it is difficult to calculate accurately the value of this time factor. He derived, from the laws of radiation, the following formula giving the coefficient of heat transfer by radiation:

$$\alpha_R = \frac{0.362\left[\left(\frac{T}{100}\right)^4 - \left(\frac{T_w}{100}\right)^4\right]}{\left(\frac{1}{A_1} + \frac{1}{A_2} - 1\right)\left(T - T_w\right)}$$

kg. cal. per sq. m. per deg. cent. per hr. where T and T_w are the absolute temperatures, and A_1 and A_2 the absorptive capacity of gas and wall, respectively. He calculated for his closed-vessel experiments this coefficient α_R, subtracted it from the observed coefficient of the total heat transfer, and took the remainder as the coefficient of heat transfer by conduction α_c. These, with the time factor, are shown diagrammatically in Fig. 9. Thus he deduced the equation $\alpha = 0.0178 \times T \times \gamma^2/_3$ kg. cal. per sq. m. per deg. cent. per hr., where γ is the density of the gas. Eliminating γ, using the characteristic equation, the value for α_c now becomes

$$\alpha_c = 0.99\sqrt[3]{p^2T}$$

where p is expressed in metric atmospheres, a relationship holding good for the cooling of any quantity of a gas at constant volume.

To apply this formula to the internal-combustion engine Nusselt derived an additional term to take into account the mean

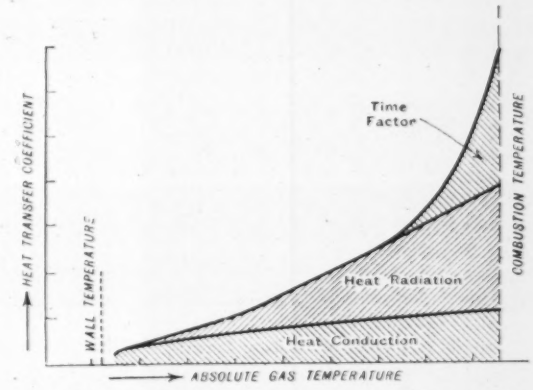


FIG. 9 DIAGRAMMATIC ANALYSIS OF HEAT TRANSFER (NUSSELT)

piston speed W. From other tests he received support for his formula, and concluded that the coefficient of heat transfer in internal-combustion engines is $\alpha = 0.99\sqrt[3]{p^2T}\,(1 + 0.24\,W)$ in the same units as before.

In concluding, Professor Nägel mentioned some tests he had made recently upon an opposed-piston Diesel engine at the Junkers works in Dessau. The cylinder diameter was 160 mm. and the strokes of the upper and lower pistons 240 mm. and 320 mm. (9.44 and 12.59 in.), respectively. At the normal speed, 160 r.p.m., the engine developed 60 b.hp. with a brake m.e.p. of 6.3 atmos., i.e., 90 lb. per sq. in. Sixty-four thermocouples were placed at different points along and around the liner. Half of these thermocouples were 3.2 mm. (0.12 in.) distant from the inner wall, the other half at a distance of 15.0 mm. (0.59 in.) from the inner wall, or about 3.0 mm. (0.11 in.) from the outer wall of the liner. The object of the tests was to find the rate of heat transmission of the different zones of the cylinder liner. In the combustion zone, i.e., between the pistons when at inner dead centers, the temperature reached nearly 200 deg. cent. (Prof. Adolph Nägel in *The Engineer*, vol. 144, no. 3745, Oct. 21, 1927, pp. 459–460, 4 figs., *hpA*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

Seventh International Conference on Weights and Measures[1]

A REMARKABLE advance toward complete international agreement on fundamental questions of measurement took place at the 7th International Conference on Weights and Measures, held last September in Paris. At this conference the United States was represented by the Director of the Bureau of Standards. The present year is the 50th anniversary of the establishment of the International Bureau of Weights and Measures.

The conference just held was the most important in point of results secured since the first conference in 1875. The actions taken affect fundamentally many kinds of measurements and standards, and are based on the results of scientific research covering many years. The new decisions involve (1) the international temperature scale, (2) the fundamental standard of length of the world, and (3) the basis of the world's electrical units.

Under the treaty of May 20, 1875, there was established the International Committee on Weights and Measures, the International Bureau of Weights and Measures, and the International Conference on Weights and Measures. The treaty, to which 31 of the leading governments are now parties, gives the conference jurisdiction over the fundamental problems affecting the international metric standards and precise metrology

Immediately before the conference Director Burgess met with the representatives of the national laboratories of Great Britain and Germany, and in an informal conference these three nations agreed on every value for the international temperature scale. These values were accepted by the international conference, with the understanding that an international committee would be chosen to study the matter of temperature measurements and recommend such revisions as may be found necessary in the future.

International Standard Temperature Scale

The significance of the final adoption of the international temperature scale by 31 nations is a matter of great interest to science and industry, so a brief summary of the desirable ends thus assured is given below.

1 A uniform basis for expressing all quantities involving temperature and heat measurement, such as tables of properties of refrigerants, steam tables, heats of combustion, specific and latent heat of materials, and particularly fixed temperatures, such as freezing, boiling, and transition temperatures of substances.

2 A uniform basis for calibration of all temperature-measuring instruments, particularly those for export from one nation to another. This is particularly important in the case of pyrometers for use at very high temperatures.

3 A common basis in all countries for the certification of precision temperature-measuring instruments for use in all precise experimental or research work involving temperature measurements. Such basis is now so well defined and universally understood as to make it unnecessary for the researcher in publishing his results either to establish or define his own temperature scale as has often been necessary in the past.

International Standard for Length

The proposition of the United States to define the length of the international meter in terms of the wave length of the red radiation from the cadmium lamp was also tentatively adopted, the final wording of the recommendation as decided upon by the conference being an improvement on that submitted by the United States. As a result of this action, there is now established a permanent natural standard of length, easily reproduced, capable of being used in the most precise measurements we are ever called upon to make. Although the particular line chosen in the spectrum of cadmium is believed to be a very good one for this purpose, the way has been left open to utilize a better line, such as one of those in the spectrum of krypton, if future investigations prove this to be desirable.

The conference tentatively adopted the value determined by Fabry and Perot in 1906 as expressing the relation between the international meter and the wave length of red light from cadmium vapor. This relation is 1 meter = 1,553,164.13 waves under certain definitely stated standard conditions.

The wave length of cadmium light is thus accepted as a standard in terms of which lengths may be measured and other light-wave standards may be expressed. This action is of great importance because of the fact that many precise length measurements in science and industry are now made in terms of light waves, and particularly useful for setting up and intercomparison of gage blocks and other subdivisions of the meter.

The matter of standard temperatures at which end standards (gage blocks) shall be certified was also considered in connection with length measurements. It is desirable to employ a temperature at which the blocks are actually used. At present, there are many variations in the practice of different nations.

[1] Abstracted from the *Technical News Bulletin* of the U. S. Bureau of Standards, November, 1927.

Notice of Change in Standards for Cast-Iron Flanged Fittings

IN THE August, 1927, issue of Mechanical Engineering an abstract of the proposed Tentative American Standards for 125- and 250-Lb. Cast-Iron Pipe Flanges and Flanged Fittings was printed for the information of the members of the Society. The Sectional Committee which developed this proposal from the tables published in 1914 is now voting on a change in the "Materials" section of the Introductory Notes to these two standards. A copy of this section in its revised form is reproduced below:

Material. The dimensional standards for cast-iron fittings covered herein are based on a high-grade product. The physical and chemical requirements of these flanges and fittings shall be in accordance with Table 1. These requirements are recommended in the absence of similar data in the Specifications of the A.S.T.M. applicable to cast iron intended for the manufacture of pipe flanges and fittings pending the preparation of an acceptable specification.

TABLE 1 PHYSICAL AND CHEMICAL REQUIREMENTS OF CAST-IRON FLANGES AND FLANGED FITTINGS

Casting	Tensile strength in lb. per sq. in., minimum	Sulphur, per cent maximum
Light[1]	20,000	0.12
Medium[2]	21,000	0.12
Heavy[3]	24,000	0.12

[1] Light castings are those having any section less than 1/2 in. thickness.
[2] Medium castings are those not included in either of the above classes.
[3] Heavy castings are those in which no section is less than 2 in. in thickness.

It should be noted also that this section in its revised form will replace the similar material which now forms part of the preliminary drafts of the standards for Long-Turn Sprinkler Fittings and 25-Lb. Cast-Iron Pipe Flanges and Flanged Fittings.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK,
Aeronautic Division
A. L. KIMBALL, JR.,
Applied Mechanics
H. W. BROOKS,
Fuels Division
R. L. DAUGHERTY,
Hydraulic Division
WM. W. MACON,
Iron and Steel
JAMES A. HALL,
Machine-Shop Practice Division
CHARLES W. BEESE,
Management Division
G. E. HAGEMANN,
Materials Handling Division
J. L. WALSH,
National Defense Division
L. H. MORRISON,
Oil and Gas Power Division
W. R. ECKERT,
Petroleum Division
F. M. GIBSON and W. M. KEENAN,
Power Division
WINFIELD S. HUDSON,
Printing Machinery Division
MARION B. RICHARDSON,
Railroad Division
JAMES W. COX, JR.,
Textile Division
WM. BRAID WHITE,
Wood Industries Division

Applied Mechanics

Courses in Applied Mechanics[1]

AM-1 Are advanced courses in Applied Mechanics, particularly in dynamics, needed?

(*a*) Regarding G. B. Karelitz's discussion of this subject in the December, 1927, issue of MECHANICAL ENGINEERING, the writer would say that he heartily agrees with the main thesis.

At Yale for some years the senior mechanical engineers have been given a two-hour course, extending through the year, entitled Mechanics of Machinery. The subjects treated include static and dynamic balance, vibration, gyroscopic motion, the dynamics of hoisting machinery, governors, and the reciprocating-engine mechanism, including flywheel problems for both reciprocating engines and impulse machines, the balancing of multiple-crank engines, and some discussion of the transmission and absorption of power by belt and rope drives. This course follows the usual courses in analytical mechanics, kinematics, and machine design, of the junior year. It is taught by the Mechanical Engineering Department staff. No attempt is made to elaborate the mathematical or highly theoretical aspects of the phenomena considered. The primary object of the course is to develop a capacity to analyze a physical condition and by synthesis to arrive at a solution of concrete problems or projects, comparable to those that present themselves to the designing or operating engineer in his every-day experience. Emphasis is placed upon a correct appreciation and visualization of the problem, and the fundamental relationships between the determining physical factors involved as a preliminary to the selection of the proper mechanical or analytical tool by means of which to arrive at the desired solution. In other words, the effort is to develop a capacity to reason from the conditions presented to a concrete result.

We have found that simple problems, related as far as possible to current engineering practice, develop an interest and awaken more independent effort than any formal textual material. The self-reliant student with initiative and mechanical instincts will visualize and analyze the physical factors in any given case with comparative ease. The writer believes that there is relatively little difficulty experienced in selecting the fundamental formula which expresses the relationship between these factors in a form suited to the purpose in view. But what about the student who does not visualize readily, and has little or no instinctive mechanical perception? Every teacher of mechanical engineering knows that many such men manage to graduate in every class, and some with fair distinction, by sheer intellectual effort. Such students must be led to appreciate first the physical factors as actual phenomena which can be pictured mentally and more or less well represented by some sort of sketch or schematic diagram. From the representation thus presented, he can be led to an appreciation of the kind of influence which each factor contributes to the resultant effect. Then of course come the evaluation of the relationships in terms of the symbols of analytical mechanics, and the mathematical manipulation required to bring into prominence the particular relationship or unknown factor desired. Formal mathematical training, and to a considerable extent the usual type of training in physics and analytical mechanics, by the very necessity for emphasis upon mechanical processes and formulas, tend to create habits of memorizing and repetition by rote which enable the student to make a fair showing in such courses if he applies himself diligently. We may call attention to these processes as merely the tools of the engineer, but to the student their mastery is of importance primarily because his promotion and diploma depend thereupon. How can he grasp their effectiveness as tools for a purpose entirely outside of their specific domain until with attention focused upon this ultimate purpose he looks about for means which will aid him in its accomplishment?

Here we have the justification for Mr. Karelitz's point of view. The writer would include in every mechanical engineering course a substantial amount of drill on problems involving the phenomena of vibration, balancing, gyroscopic action, governors of various types, particularly inertia governors, etc. How otherwise can the student obtain any concrete idea of the way in which the engineer finds, faces, and fathoms his problems?

The thorough mastery of a very few representative problems involving these technical procedures is of vastly greater importance than the routine doing of a large number of exercises and problems, always getting the right answer by the substitution of given data in stipulated formulas. It is hard on the average and sub-average student. It is harder on the instructor, but salvation is not without effort even in a treadmill. Once the idea of the tool value and tool aspect of the "fundamentals" is appreciated, the capacity for independent reasoning and an illuminated interest follow, as night the day. This, and this alone, is education. (S. W. Dudley, Chairman, Department of Mechanical Engineering, Yale University.)

[1] This subject has been discussed in a previous issue.

(*b*) The writer has read with much interest G. B. Karelitz's contribution on applied mechanics in the December, 1927, issue of MECHANICAL ENGINEERING. Apparently he has a very clear conception of the need for the more thorough theoretical training of mechanical engineers in mechanics. The writer believes that he is correct, as we have found here at the Bureau of Standards that engineering training which is apparently satisfactory in commercial work does not give the grasp of fundamentals which is desirable for our work. Please remember that many of our problems are very simple in comparison with those which occur in commercial work. It is nevertheless very desirable to have the engineers in this country more thoroughly trained. It seems probable that electrical and chemical engineers have a much better fundamental training than mechanical engineers. Better training of engineering graduates would result in more satisfactory solutions of mechanical-engineering problems, thereby contributing to the economic gain of the country. (H. L. Whittemore, Bureau of Standards, Washington, D. C.)

(*c*) This is a very interesting problem. Undoubtedly, there is too little mechanics taught for those who go into design fields. But how many are there? And what are we to leave out of the present curriculum? It seems to the writer that by the end of the junior year it is usually possible to have covered only the most elementary fundamental engineering adaptations of physics, thermodynamics, mechanics, including hydraulics, and electrical engineering theory. The fourth year is usually devoted to applications in various branches of engineering, power plants, heating and ventilation, machine design, refrigeration, etc. So much work presents itself here (and no mention has been made of the economics and industrial engineering courses so essential) that not every student can do it all in one year. Dr. Tyler and the writer decided that the most practical solution was to let men elect a group of studies either in mechanics and design or in heat-power, during their fourth year, rather definitely preparing for careers in one of these two fields. We felt that the courses thus given could be more adequately taught by giving additional time at the expense of something omitted. (G. A. Stetson, Associate Professor, Heat-Power Engineering, New York University.)

Materials Handling

PULSATION IN CHAIN CONVEYORS

MH-1 In slow-moving chain conveyors operating at rates as low as or even less than 1 foot per minute there is often present a decided pulsation or jerking of the chain. At times, however, operation is smooth. Can any of the readers suggest a solution of this problem or mention a possible cause of the difficulty?

(*a*) Relative to this subject as discussed in the December, 1927, issue of MECHANICAL ENGINEERING, the writer's experience leads him to believe that the pulsations may be due to one of the following two causes:

1 Improper meshing of eccentric gears.
2 Lost motion due to loose key in driving gear.

It is suggested that all set screws be loosened and the slack taken up with a pinch bar, then tightened thoroughly. (C. M. Ware, Pocatello, Idaho.)

(*b*) It is the writer's opinion that tension is built up along the tread of the structural-steel frame supporting the chain, and as the power pulls the chain the load is released at intervals, resulting in the jerky operation of the conveyor. It seems doubtful that there are any power conveyors built, particularly where the friction of the apron is quite an item, without pulsation appearing in operation. However, the greater the speed of operation the less noticeable should be the pulsation, and, vice versa, the slower the conveyor the more elastic will become the chain, resulting in greater pulsation, regardless of pitch of chain and diameter of sprockets. (M. Nelsen, Chief Engineer, Matthews Conveyor Co., Ellwood City, Pa.)

Miscellaneous

SYMBOLIZATION OF STANDARDS

M-1 The subject of symbolization of standards on a national basis, although of primary interest to mechanical engineers, has never been discussed in this country apparently for lack of interest. Comments from members should prove of value.

Since national standards greatly affect relations between companies, uniform symbolization of A.E.S.C. standards would appear to have the following advantages:

1 Provide a uniform "language."

2 Eliminate translation of symbolization of one company to that of another. What the producer calls TJLS2 may be 9227C of a consumer under present practice.

3 Save symbolization by individual companies.

4 Save publication expense, since a seller can furnish a copy of the A.E.S.C. standard sheet and price sheets referring to standard symbols. To users and manufacturers of machine bolts, for example, the A.E.S.C. symbol would soon become as well known as U.S.S. or S.A.E.

5 Advertise A.E.S.C. standards, thus adding momentum to national standardization. It is not necessary to wait until all data (material, tolerances, etc.) are complete before assigning and using the symbol of an article. Unstandardized characteristics can be covered by name only, as "commercial steel," "bronze," "smooth finish," etc. As additional characteristics of an article become stabilized and standardized, revised sheets can be issued. The revised sheets can be differentiated from the old by date of issue only, except when interchangeability is affected, when the symbol should be changed. (F. A. Buese, Works Standards Department, Fairbanks, Morse & Co., Beloit, Wis.)

MANUFACTURE OF CONDENSATION PRODUCTS

M-2 Briefly, what methods are used in the fabrication of the various condensation products, such as bakelite, etc. into the various forms in which they are marketed?

Fabrication of laminated stock utilizes many of the standard practices common to the working of metals and wood, the understanding of numerous variations in the technique being, however, essential.

Molding materials are usually in finely powdered form and are composed of phenol resinoid, fibrous reinforcing materials such as wood flour, asbestos, etc. and color pigment. They are fabricated into the finished objects—automotive distributer heads, radio dials, telephone mouthpieces, etc.—by brief molding operations in steel dies on hydraulic presses.

The laminated stock is a dense, uniform material, embodying layers of canvas, linen, or paper, bonded with bakelite resinoid, and pressed into sheets, tubes, and rods, under the application of heat and high pressure, in hydraulic presses. From these primal laminated forms finished articles are fabricated by machining rather than molding. The finished objects are typified by silent industrial and automotive gears, radio panels, and insulation accessories. (L. V. Quigley, Technical Editor, Bakelite Corp., New York, N. Y.)

ELIMINATION OF DYE-HOUSE STEAM[1]

M-3 What is the latest practice in the elimination of steam from dye houses and similar establishments?

The answer to this quotation published in the November, 1927, issue is, to say the least, incomplete. Why should a boss dyer purchase equipment for the abatement of the "fog" nuisance when proper temperature control would eliminate it at its source? Dye-house fog results from overboiling, which is utterly wasteful. Dye liquor is almost always heated by perforated steam pipes, and the tendency of dyers to open wide the steam valve in order to get a violent boil arises from the mistaken belief that the dyestuff will penetrate better and the process will take less time. As a matter of fact, maintaining a temperature of 206 or 208 deg. fahr. has been found to give even better results than does a violent boil, and fog is almost completely eliminated. Moreover there is a considerable saving in steam, and in the case of most materials there is no danger of damage to the fibers (matting, felting, etc.) such as occurs when the boil is violent. (M. J. Béhar, C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.)

DRAFTING-ROOM LIGHT EXPOSURE

M-4 What have been the observations of readers regarding the effect of light in the drafting room, that is, the direction of exposure of windows?

The writer's observations have been that where the windows are located on the west side of the room the effect of the sun is to produce a blinding light and a disagreeable heat condition. At one time an opportunity was offered to observe the effect of light from windows facing the north. The effect was remarkable. The room was comfortable, and there was a decidedly pleasant lighting effect, as compared with the harmful and unpleasant conditions accompanying the western exposure. Colds were prevalent in the room with western exposure, while the room with light from the north did not affect the men in this respect at all. It is the writer's belief that the best, most healthful, and most efficient results are obtained by working alongside of north windows, the light from this quarter being the least blinding. The south light is harmful, as is also the west, and the eastern exposure results in a light next in preference to that from the north. (H. E. Larson, Racine, Wis.)

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

The Most Economical Condenser

TO THE EDITOR:

The discussion of the paper on condensers by Messrs. J. A. Powell and H. J. Vetlesen has brought out much interesting comment, and after reading this, one is likely to come to the conclusion that as a matter of fact either the two-pass or the single-pass condenser will give very satisfactory results, and that the actual conditions at a particular plant would be the determining factor as to whether a two-pass or a single-pass is the best. Also it seems to be indicated that there is comparatively little difference between a properly designed double-pass or single-pass condenser. It has, however, occurred to the writer that some mention of the desirability of using condensers with vertical tubes might be in order.

In numerous recent very large installations vertical condensers have been used, and these appear to be very successful. If this is looked into from the practical point of view it will be found that the vertical type has numerous practical advantages as follows:

a Less liability to fouling of surface. The tubes being vertical, large or hard particles are less likely to stay in them. More dirt will collect in water boxes than in horizontal condensers.

b They can be washed out or cleaned more easily if the fouling matter is soft, and the expense of cleaning is probably less.

c The condensate will run down along the tubes, and it is likely that this will have a less deleterious effect than the dripping from one tube to another that is experienced in horizontal condensers. This is probably a small point, but there may be some small advantage.

d The air in the condensate naturally falls to the bottom, where if drawn off from the inlet side it will come in contact with the coolest surface Air blanketing is therefore reduced.

e The tubes do not require supporting plates and hence there is little interference with the distribution of the exhaust vapor, so that the entire surface of the condenser is effective. The air separates naturally and with as little interference as possible.

f A close connection to the turbine exhaust can be made, and simpler foundations are possible.

g It is possible to work in a better design of water box so as to avoid churning action and the absorption of air by circulating water. This would tend to reduce tube failures.

h Due to their vertical position all tubes are more likely to receive their proper share of water, and reversal of flow is less likely to take place. All tubes are always full of water. The top water chest can be more readily vented to remove air that may collect.

i The condenser as a whole is freer to expand or contract to suit temperature conditions.

j A vertical condenser lends itself better to the practice of expanding tubes at both ends without recourse to bent tubes; hence less leakage than in a condenser with packed tubes.

k Since the water is distributed better, a greater condensing effect from the same amount of circulating water would probably be secured.

While none of the above-mentioned advantages have any very great effect individually, when taken in the aggregate they may amount to considerable. Will not the users of vertical condensers come forward and give us some information as to their experience and possible corroboration of the assumed advantages that are herein set forth? It would be pertinent for the A.S.M.E. Committee on Condensers to investigate this matter, particularly from the standpoint of tube failures. It would seem that where structural conditions permit, the use of vertical condensers (two-pass preferred) is preferable to that of either single- or double-pass horizontal condensers. In naval or marine work the vertical condenser would not be feasible, and here the single-pass condenser, as installed on destroyers, with tubes expanded at both ends, gives the most satisfactory results. Some of these condensers in naval vessels give a heat absorption per square foot of surface nearly double that secured in power-plant practice. But here the amount of cooling water available is unlimited, and weight and space are material factors to consider.

H. C. DINGER.[1]

Annapolis, Md.

[1] This subject has been discussed in a previous issue.

[1] Captain, U.S.N.; Head Engineering Experiment Station, U. S. Naval Academy.

Fusion Welding and the Mokelumne Pipe Line

TO THE EDITOR:

The November issue of MECHANICAL ENGINEERING, page 1209, presented a discussion of the merits of fusion welding versus riveting, etc. in which the Mokelumne pipe was mentioned as an example of acceptable arc welding in the manufacture of the pipe sections, but of failure of field welding by the oxyacetylene process, and the substitution of riveting in the case of the transverse seams.

This matter was the subject of a lengthy discussion at a joint meeting of the American Welding Society and the A.S.M.E. held in New York in May, 1927, in which Prof. L. T. Jones, of the University of California, presented a paper covering an exhaustive investigation of the stresses set up in a pipe by the longitudinal expansion and contraction due to atmospheric temperature changes and the direct heat of the sun on the pipe as it lay in the trench, also the effect of this continuous creepage on the welded or partially welded seams. The paper and discussion were published in the June, 1927, *Journal* of the American Welding Society.

FIG. 1 LAYING 44-IN. PIPE LINE FROM CRYSTAL SPRINGS TO SAN FRANCISCO IN 1884

The selection of electrically welded pipe for the Mokelumne project attracted the attention of engineers throughout the country, as well as others interested in the economics of this line of work, as it is the first time that this type of construction has been recognized as an equal to Lock Bar or riveted pipe for this particular service, and while Lock Bar pipe was specifically mentioned in the request for tenders, the manufacturers failed to submit unit prices on the different schedules.

The writer, who has had a very considerable experience in the manufacture and laying of large riveted pipe lines, through early association with Messers. Schussler[1] and Moore,[2] who were pioneers in this line of activity, has watched the installation of the Mokelumne line with perhaps more than ordinary interest, and must say that there is a wide variance in the field procedure today from the practice of 1880 to 1895 when the main supply lines of the Spring Valley Water Works were being installed under Mr. Schussler's supervision. The photograph reproduced in Fig. 1 was taken during the laying of the Crystal Springs 44-in. line to San Francisco in 1884. Note the last length being placed, also the backfilling on the third pipe. The riveting of the transverse seams is seen to be following apace, the trench is being immediately backfilled, and there are no thousands of feet of partially covered pipe exposed awaiting the engineer's test, as no tests are made until the pipe is ready for service. Schussler's system of installation was to limit the number of lengths of pipe uncovered at the end of the day's work to five (140 ft.), and any long section of the line exposed to atmospheric temperature was to be riveted permanently in 1000-ft. sections. These sections were finally assembled at night and filled with water, and the pipe in the trench was also filled with water prior to the rainy season to prevent its floating out.

It might be inferred that the temperature conditions in this case were not similar to that experience on the Mokelumne conduit, but the writer would say that he was in the field during the completion of the Niles-Burlingame line[3] in 1888, and that 100 deg. and over was common during the midsummer months; further, there were some miles of the conduit on a trestle that had been assembled and riveted complete in 1000-ft. sections with a suitable space between the ends for expansion. Bands in halves were temporarily bolted to one end of each section for future final assembly, the pipe was closely boxed to obstruct the direct rays of the sun, and from observations of it from time to time the expansion was seen to amount to as much as five inches. Incidentally, the scraping of the free end of the bands on the adjoining pipe made its own "expansion graph," with no evidence of distress from locked-in stresses.

The *Engineering News-Record* of January 28, 1926, describes the installation of a 66-in. riveted pipe line in which the "creepage" during installation is given as amounting to 3 ft.

The writer's object in presenting these facts is that in the discussion before the American Welding Society referred to above, no one seemingly questioned the requirements of the specification for this part of the work. As a matter of fact, consideration must be given to the possible effect of atmospheric temperature changes in all metal work, as may be observed on railroad lines, bridges, thermit-welded car tracks, and as in the above-described pipe line, in order to be assured of dependable construction.

W. J. DYER.[4]

Berkeley, Calif.

[1] Herman Schussler, Hydraulic Engineer and Chief Engineer of Spring Valley Water Works, San Francisco.

[2] Joseph Moore, Manager Risdon Iron Works, San Francisco.

[3] Thirty-four miles of 36-in.-diameter riveted pipe.

[4] Mem. A.S.M.E.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 551 (reopened), 552 (reopened), 558, 563, 564, 565–568 inclusive, as formulated at the meeting of October 28, 1927, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 551 (REOPENED)

Inquiry: Will it be permissible to form a nozzle on a drum of diameter not less than 30 in., where the shell is 2 in. or more in thickness, by the use of a steel tube not exceeding 3 in. in diameter, which is rolled into a hole in the drum and into an outer flange? Attention is called to the fact that if a flanged nozzle were to be attached to a drum by riveting as required in Par. P-268 of the Code, the rivets would become so long that it would be difficult to make a tight and satisfactory joint, and also it is believed that the method of screwing a threaded pipe connection into the drum as provided for in Par. P-268 would be unsatisfactory on account of damage to the threads through corrosion or other means.

Reply: A revision of the requirement pertaining to nozzles in Par. P-268 is being considered which will modify the present mandatory requirement for the riveted attachment to shells or drums. It is the opinion of the Committee that the proposed construction is allowable under the conditions specified provided the outside diameter of the tube does not exceed 4 in. In all cases the tube used for the nozzle shall conform with the requirements of Pars. P-21 and P-251.

CASE NO. 552 (REOPENED)

Inquiry: Is it necessary in purchasing base metal plate for welded steel low-pressure heating boilers, to specify firebox quality for plates that are to be exposed to the products of combustion, or is any good soft grade of steel acceptable for this purpose?

Reply: Pars. H-74 to H-77 of the Code are intended to cover steel plate of either flange or firebox quality, the chemical and physical requirements to be in accordance with Pars. H-74 and H-76. In all other respects the steel should conform to the Specifications for Steel Boiler Plate, Pars. S-5 to S-17 of Section II of the Code, provided the carbon does not exceed 0.20 per cent. Such material is practically the same as that covered by the Specifications for Steel Plate of Flange Quality for Forge Welding, Pars. U-110 to U-125 of Section VIII of the Code, and it is the intention of the Committee to revise Par. H-74 to conform to Par. U-70 of Section VIII of the Code. Pars. U-112 and U-115 have already been revised to permit the use of two grades of material, Grade A being the same as before and Grade B permitting a maximum carbon content of 0.20 per cent and a corresponding minimum tensile strength of 50,000 lb. per sq. in.

CASE NO. 558

Inquiry: *a* Is it permissible, under the requirements of Par. U-39 of the Code, to reinforce a dished head with a manhole ring without a flange of such size and thickness as to compensate for the metal removed from the head?

b Can this ring be placed on the pressure side of the head and then fastened thereto by welding first the outer edge of the manhole ring to the head and then the inner edge of the ring to the manhole opening edge, or must such attachment be made with rivets?

c Is this requirement met by welding a ring into a manhole opening in a dished head if such opening and the ring are concentric with the axis of the vessel?

Reply: *a* and *b* Inasmuch as Par. U-39 of the Code requires a head to be flanged for a manhole opening, the use of a separate ring is not permissible.

c Inasmuch as Par. U-39 requires the opening in a dished head to be flanged, no other construction is permissible under the Code.

CASE NO. 563

Inquiry: Is it the intent of Par. P-289 of the Code, which requires flanged inlet connections for safety valves mounted on superheaters, that this rule shall apply when the superheaters are attached to h.r.t. boilers operating at pressures not to exceed 150 lb. and superheat temperatures not to exceed 450 deg. fahr.? It is pointed out that the safety valves used on such h.r.t. boiler superheaters are 2 in. in size and that the superheating service is not severe on this class of boiler.

Reply: Par. P-289 is specific in its requirement for flanged safety-valve inlet connections to superheaters.

CASE NO. 564

Inquiry: Is it to be understood that under the requirements of Par. P-268 of the Code steel-plate reinforcing pads may be welded on the inside of boiler shells and not conflict with the provision for welding in Par. P-186? It is also desired to use this method of reinforcement on down-draft boilers for the pipe-plug closures of the access openings to the water-grate tubes.

Reply: Par. P-268 does not specify the method of attachment of reinforcing pads, but Par. P-186 provides for the application of fusion welding only where the stress is carried by other construction. There is nothing in the Code to prohibit the construction shown provided the welding is only for tightness and not for strength.

CASE NO. 565

Inquiry: Is it permissible, under the requirements of the Code, to construct a furnace with an OG connection at a lap-riveted joint having the overlapping plate at the joint cut away along the OG curve so that when the plates are brought together they will form a butt joint and result in single plate thickness along the OG, the butt joint and the overlapping edge to be joined and made tight by fusion welding?

Reply: There is nothing in the Code to prohibit the construction described provided the stresses are carried by other forms of construction which conform to the Code.

CASE NO. 566

Inquiry: Is it permissible, under Par. P-323 of the Code, to use a hanger construction formed from a plate or strap with supporting point at the center and attachment to the shell by groups

of riveting at the two ends? Hangers have been extensively used with the rivets in two groups, hence not evenly spaced as required by Par. P-323.

Reply: It is the intent of the Code that the construction should avoid concentrated stresses, and a revision of the Code is under consideration to provide for accomplishing this in a more general way than the paragraph in question calls for.

CASE NO. 567

(In the hands of the Committee)

CASE NO. 568

Inquiry: Will it be permissible, under the requirements of the Code for Unfired Pressure Vessels, to form the heads of a steam and water drip tank, not to exceed 24 in. in diameter, intended for operation at 400 lb. pressure, by inserting dished heads with the concave side to pressure in the ends of lap-welded pipe or tubing and crimping the ends of the pipe or tubing down over the knuckle of the dished head, using fusion welding for tightness? It is noted that Par. U-74 specifies the length of flange for dished heads concave to pressure but does not specify other than in the illustration in Par. U-3*j* as to its method of attachment to the shell.

Reply: There is nothing in the Code for Unfired Pressure Vessels to provide for this form of construction. If fusion welding is to be used to attach the head to the shell of a vessel, the weld should be made in accordance with the method illustrated in Fig. U-3*j* and the head thickness reduced to that of the shell as specified in the last sentence of Par. U-74.

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules in its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

During the past two years the Boiler Code Committee has received and acted upon a number of suggested revisions which have been approved for publication as addenda to the Code. These are published below, with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticisms and comment thereon from any one interested therein. Discussions should be mailed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

After 30 days have elapsed following this publication, which will afford full opportunity for such criticism and comment upon the revisions as approved by the Committee, it is the intention of the Committee to present the modified rules as finally agreed upon to the Council of the Society for approval as an addition to the Boiler Construction Code. Upon approval by the Council, the revisions will be published in the form of addenda data sheets, distinctly colored pink, and offered for general distribution to those interested, and included in the mailings to subscribers to the Boiler Code interpretation data sheets.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals, and all deleted matter in smaller type.

Par. H–1. Revised:

H–1. These rules for steel-plate boilers shall apply:

a To all steam boilers for operation at pressures not exceeding 15 lb. per sq. in.

b To [steel plate] hot-water boilers TO BE OPERATED AT PRESSURES not exceeding [60 in. in diameter or] 160 lb. [working pressure] PER SQ. IN., or temperatures not exceeding 250 deg. fahr.

c For conditions exceeding those specified above, the rules for construction and setting of power boilers shall apply.

Par. H–70. Revised:

H–70. Steel-plate boilers constructed by autogenous welding under the rules prescribed for steel-plate heating boilers may be used for steam heating at pressures not exceeding 15 lb. per sq. in., or for hot-water heating at pressures not exceeding 160 lb. per sq. in., OR FOR TEMPERATURES NOT EXCEEDING 250 DEG. FAHR. For pressures in excess of 30 lb. per sq. in. for hot-water boilers, the factor of safety for autogenously welded steel-plate boilers shall be not less than 5, assuming the strength of the welded seam at 28,000 lb. per sq. in. of net section of plate.

Par. H–74. Revised:

H–74. *Material for Base Metal.* The base metal composing the plates of autogenously welded steel-plate heating boilers shall be of good weldable quality and shall be made by the open-hearth process, conforming to the requirements of the Specifications for Forge Welding, Pars. U–110 to U–125 of Section VIII of the Code, or to those for flange and firebox classes of steel given in Pars. S–5 to S–17 of Section II of the Code, provided the carbon does not exceed 0.20 per cent.

M–17. Revised:

M–17. Each steam line from a miniature boiler shall be provided with a stop valve located as close to the boiler shell or drum as is practicable, EXCEPT WHEN THE BOILER AND STEAM RECEIVER ARE OPERATED AS A CLOSED SYSTEM.

Proposed Addenda

In the preamble of the 1924 edition of the A.S.M.E. Boiler Construction Code a statement was made that the general rules appearing in the 1918 edition covering pipe flanges and fittings were repeated therein for the reason that the report of a Committee working under the American Engineering Standards Committee to revise and enlarge this standard for application to higher pressures, had not then been completed. The new Tentative American Standard for Steel Pipe Flanges and Flanged Fittings has, however, now been completed and approved by the A.E.S.C. (in June, 1927), and it is now issued in pamphlet form.

The Boiler Code Committee now has under consideration the adoption of these new standards and incorporating them in the Power Boiler Section of the Code to replace the original American Standard as published in the last edition.

Any one who has special interest in this feature of the Code requirements is invited by the Boiler Code Committee to examine the new standard and study it critically with a view to offering any desired comments thereon to the Committee.

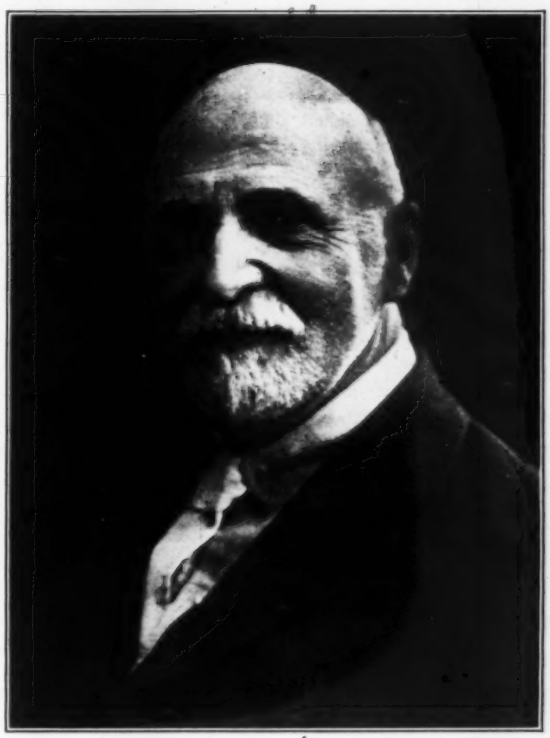
Attention is called by the Boiler Code Committee to the fact that in the new standard the $4^1/_2$- and 7-in. pipe sizes have been omitted, but as those sizes are in such extensive use in connection with boiler construction and erection, the Committee proposes to include figures to cover them, with notation to the effect that they are to be treated as special sizes.

Forty-Eighth Annual Meeting of A.S.M.E.

The Largest Meeting Yet in Point of Attendance—Twenty-Six Technical Sessions, Featuring Subjects of Timely Interest, Draw Out Valuable Discussion—Lectures and Social Events Make for Well-Rounded Program

EVERYTHING that a mechanical engineer could desire was provided at the Forty-Eighth Annual Meeting of The American Society of Mechanical Engineers in New York from December 5 through 9, 1927. There were absorbing technical sessions, with few papers at each and plenty of good discussion. There were splendid opportunities for good-fellowship at the Open House on Monday night, at the Dinner on Wednesday night, and throughout the week in the ever-popular lobby of the Engineering Societies Building. Learned men propounded abstruse theories in a forceful and interesting manner: one spoke on education, three on various phases of photography, and one on taxation. Finally, and of great importance, a group from the Women's Auxiliary took excellent care of the ladies while their husbands were immersed in the more technical phases of the meeting.

Attendance is not necessarily a measure of the success of a meeting, but the fact that 2351 appeared at the registration headquarters, thus establishing a new attendance mark, is a source of gratification to those who had the meeting in charge.



ALEX DOW — PRESIDENT, 1928

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PARALLEL EVENTS

Several other happenings in New York during the meeting contributed much to its success. The Power Show at the Grand Central Palace attracted a large number of engineers and industrial executives. This comprehensive mechanical exhibition, in its sixth year, is growing in influence in the development of mechanical-engineering devices.

The American Society of Refrigerating Engineers held its 23rd meeting at the Hotel Astor from December 5 to 7. The Power Transmission Association held a luncheon meeting at the Hotel Commodore on December 7, and the Taylor Society held its annual meeting from December 7 to 9.

As usual, the A.S.M.E. held a joint session with the A.S.R.E. The American Management Association cooperated in the sessions of the Management Division held on December 8.

PRESIDENTIAL ADDRESS AND RECEPTION

The auditorium was crowded for the presidential address, Tuesday evening, December 6, when President Schwab presented his carefully prepared discussion of "Human Engineering." This address, on the modern spirit of cooperation and helpfulness in the conduct of large industries, appears as the leading article in this issue.

Following President Schwab's address, Dr. Fred R. Low, Past-President, introduced Leon P. Alford as the first Melville medalist. Mr. Alford's paper on Laws of Manufacturing Management, which treated of the contribution of engineers to the science of management, was read at the Annual Meeting in 1926. Mr. Schwab then presented the medal to Mr. Alford, whom he cited as particularly worthy, not only on account of his paper, but because of his staunch friendship and service to the Society.

Secretary Rice presented the report of the Board of Tellers, giving the results of the letter ballot for officers of the Society. The following were declared elected:

President: ALEX DOW.

Vice-Presidents: JOHN H. LAWRENCE, E. A. MULLER, NEWELL SANDERS.

Managers: PAUL WRIGHT, F. H. DORNER, WM. A. HANLEY, L. B. MCMILLAN.

Delegates to the American Engineering Council: L. B. ALFORD, DAVID W. BRUNTON, HAROLD V. COES, ALEX DOW, ARTHUR M. GREENE, JR., JOHN LYLE HARRINGTON, DEXTER S. KIMBALL, WM. S. LEE, R. C. MARSHALL, JR.

Dr. William F. Durand, Past-President of the Society, then led the successful candidate for the presidency, Alex Dow, to the stage and introduced him to President Schwab, who in turn introduced him to the Society.

Mr. Dow accepted the office with expressions of pleasure and pledges of whole-hearted efforts to advance the work of the Society.

The scene then shifted to the fifth floor for the reception, which was followed by dancing.

THE A.S.M.E. AND ENGINEERING EDUCATION

The engineering societies have a broad responsibility and a definite place in putting the relations between the engineering profession and the engineering schools on a clearer basis. In a splendid address, Dr. W. E. Wickenden held the close attention of a well-filled auditorium for an hour as he elaborated on this theme and laid out a program which should have a far-reaching effect upon the status of the engineering profession and upon engineering education. Dr. Wickenden's address is based on

his four years' experience as Director of Investigation of the Society for Promotion of Engineering Education. The address will appear as the leading article in the March issue of MECHANICAL ENGINEERING. It was presented on Tuesday afternoon with Dr. Ira N. Hollis, Past-President of the Society in the chair.

Taxation and Industry

The most important task and opportunity of American industry in the field of taxation is to work vigorously for the clarification of tax laws and the improvement of their administration. Thus Dr. T. S. Adams, Professor of Political Economy at Yale University and President of the American Economic Association, concluded the Third Henry Robinson Towne Lecture. Dr. Adams, a world authority on taxation, revealed the power and diversity of the forces which control the shaping of tax laws, and explained the relation of these forces to the controversy now being waged in Washington over federal tax policies. His forceful and timely address was well received by a large audience. It will appear as the leading article in the February issue of MECHANICAL ENGINEERING. Harold V. Coes, Vice-President of the Society, occupied the chair on Thursday afternoon during the delivery of Dr. Adams' lecture.

The Annual Dinner

Good-fellowship, fine talks, excellent food, high conversations, simple ceremonies, and splendid toastmastering, were a few of the reasons why the Annual Dinner at the Hotel Astor on Wednesday evening was an outstanding success. Over 850 members and their ladies partook of the feast and enjoyed the dancing which followed.

Ralph E. Flanders, as toastmaster, directed the stream of wit and eloquence in a most original manner. Mr. Schwab was introduced as a "master of overtones," and by some magic trick of toastmastering, Mr. Dow was amazed to find himself introduced by one of his own steam turbines out at Trenton Channel. And so it went, with the result that the hour and thirty minutes set aside for talking from the speakers' table went very quickly.

Mr. Schwab's duty on the program as president was the introduction of the distinguished guests. This he did in his usual charming manner, paying special tribute to Worcester R. Warner who celebrated his thirteenth year as an A.S.M.E. past-president. But Mr. Schwab also delivered his valedictory as president of the Society, speaking feelingly of his year's association with the splendid group of leaders who give whole-heartedly of their time and effort in guiding Society activities. He reiterated his philosophy that "the thing worth while in life is the good opinion of those associated with you," and closed with a pledge of continuing loyalty to the Society.

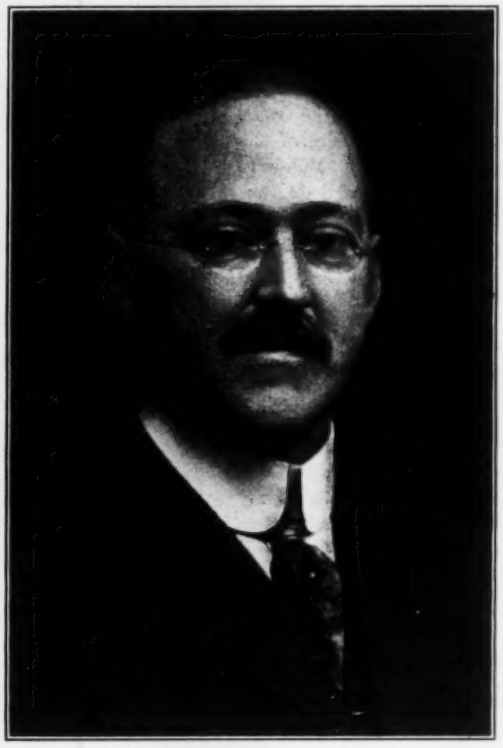
Secretary Rice then called the roll of members who joined the Society during the year. They rose in their places and received a round of applause.

William L. Abbott, Junior Past-President, delivered his charge to the new members, the text of which faces page 1 of this issue of MECHANICAL ENGINEERING.

Alex Dow, the new president, asked the help of every one in discharging his new responsibilities, which he discovered were diverse and onerous. He revealed as his philosophy his desire to so order his ways that the net result of his coming and going would be an increase in the sum total of human happiness, and he pledged his efforts to the advancement of the Society and the profession.

The last speaker of the evening was Dr. Harrison E. Howe, editor of the *Journal of Industrial and Engineering Chemistry*. Dr. Howe drew some of the evidences of present-day research from a black bag and told the romantic tales of their development. He described the magic methods that chemists followed to provide artificial silks, quick-drying paint, synthetic lemons, and countless other means of satisfying present-day demands. He closed with a toast to science, "the pilot of industry, conqueror of disease, multiplier of the harvest, explorer of the universe, revealer of nature's laws and eternal guide to truth." Dr. Howe's talk was punctuated with the laughter and applause that come from an appreciation of wit. His hearers hung breathlessly on his tale of the chemist's achievements, and after the dinner they crowded around him to hear more and to touch his exhibits.

The formal program closed with the announcement by Secretary Rice of the international engineering congress in Japan in September of 1929. Elmer A. Sperry, Chairman of the American Committee of Participation, was present and was introduced to the audience. Rising again later, Mr. Sperry pointed out that Secretary Hoover is Honorary Chairman of the American Committee and in that capacity has taken a tremendous interest in organizing the plans and in securing country-wide support for the congress. Mr. Sperry expressed the hope that every American engineer could visit Japan and see the splendid work of Japanese engineers, who have used simple, straightforward methods not hampered by precedent or tradition.



L. P. Alford, Recipient of the Melville Medal

Research Activities at 1927 Annual Meeting

A large group of the Society's research committees carried out an active program of technical sessions and committee meetings during the Annual Meeting. Beginning on Monday evening with the Main Research Committee dinner, which was attended by some 30 persons closely connected with the research activities of the Society, these meetings carried on through the week with unabated interest.

On Wednesday the Special Research Committee on Steam Tables conducted its annual open session on the progress of its

studies into the extension and accurate checking of the existing steam tables. Similar sessions were carried on the following day by the research committees on Boiler Feedwater Studies and Lubrication. All these meetings attracted considerable interest, the attendance averaging about 100 persons in each case.

In addition to these general sessions some dozen research committees and their several sub-committees met and discussed their programs as previously outlined in detail in the December 7 issue of the *A.S.M.E. News*. The attendance at these meetings totaled approximately 150 men.

The dinner meeting of the Main Research Committee on Monday evening was of particular interest as it brought together for the first time the chairmen and secretaries of the various Special and Joint Research Committees, representatives of the research Survey Committees of the Professional Divisions, and certain other interested persons. In organizing this meeting the Committee had for its purpose the creation of a better understanding of A.S.M.E. research methods and their future possibilities through an informal discussion among those particularly concerned with the development and conduct of these affairs. With the rapid growth (during the past few years) of research consciousness in industry, there has come a similar growth in A.S.M.E. research activities, and this meeting provided an opportunity for the exchange of many helpful ideas relative to the conduct of cooperative research projects in industry.

Carrying this idea further, the Main Committee distributed during the Annual Meeting copies of the "Research Activities" booklet which gives a concise statement of the scope, organization, and methods of the Society's research activities. Through its wide distribution the Committee hopes that a better understanding may be gained of the extent and possibilities of cooperative research in engineering and industry. It should be of particular value to the various A.S.M.E. Special and Joint Research Committees now active or in process of organization in the conduct and successful completion of their projects. Copies of the booklet may be obtained on request to Society headquarters.

Standards and Safety Codes

Some of the most important work of the Society during the Annual Meeting is done behind closed doors, without the public recognition which accompanies the presentation of papers and reports before the sessions. These activities are the meetings of the Technical Committees of the Society, and in no other way is the diversity and importance of the Society's work so emphasized as it is in the comprehensive list of matters which these groups of men deal with. In addition to the Research Committees which have been mentioned earlier in this account, there were ten gatherings of groups dealing with Standards and Safety Codes.

A quick glance at their transactions reveals a deal of important activity. The National Screw-Thread Commission and the American Gage Design Committee met during the meeting, the latter completing standard dimensions for cylindrical and thread-plug gages from $^1/_4$ in. to $1^1/_4$ in. in diameter.

At the meeting of the Committee on Power Test Codes, a preliminary draft of the test code for complete standard electric power plants was presented, and the final revision of the Test Code for Gas Producers was promised early in 1928.

Local Sections Delegates Conference

All but two of the sixty-eight sections of the Society were represented at the Local Sections Delegates Conference which started on Monday and continued through the next day. William A. Hanley, chairman of the Local Sections Committee, presided and conducted the discussion of items on the order of business as a result of suggestions made at an informal conference of Sections representation at the Spring Meeting at White Sulphur Springs. These suggestions included topics for meetings, cooperation with student branches, standards of membership, increasing the influence of the Society publications, and the encouragement of the Society to participate more fully in public affairs.

At the luncheon on Monday at the Hotel Astor, delegates gathered with members of the Council and chairmen of its standing committees to hear a few words from President Schwab and President-Elect Dow. Tuesday morning the seven geographical groups met separately to select the Nominating Committee and to develop plans for Regional Spring Meetings and National Meetings of the various Professional Divisions. On Tuesday afternoon the Conference prepared resolutions to the Council on the items discussed during the meetings.

A special greeting was extended to the representative of the new section at York, Pa., which was authorized by the Council at its meeting on Monday morning.

Student Branch Conference

Following a luncheon at the Fraternity Club on Wednesday, which was addressed by President-Elect Alex Dow, the representatives of some thirty student branches met to discuss problems of common interest. W. H. Cavanaugh, chairman on the Committee on Relations with Colleges, presided. The student themselves presented and discussed important questions having to do with student-branch operation. A large number of those present participated and revealed a grasp of Society problems which promises well for the future of the Society when these men take positions of leadership in it.

Excursions

Four excursions were conducted during the meeting. On Tuesday the party visited the new pulverized-fuel plant of the New York Steam Company at Kip's Bay, and the new East River Station of the New York Edison Company. On Wednesday the Greenpoint Works of the Brooklyn Union Gas Co. and the Hudson Avenue Station of the Brooklyn Edison Co. were visited On Thursday there was a round-trip bus ride to Jersey City through the Holland Tunnel.

Other Society Events

The Open House on Monday evening, conducted by the Philadelphia Section, gave a large amount of enjoyment to the 400 who were present. Simultaneously, the Women's Auxiliary conducted a similar affair for the ladies on the eleventh floor of the Engineering Societies Building, where pleasant entertainment and refreshments were provided.

The Fourth Annual Luncheon and Annual Meeting of the Women's Auxiliary was held Tuesday afternoon at the Fraternity Club Building. Dean Virginia Gildersleeve of Barnard College spoke.

On Wednesday, the Annual Ladies' Tea, Reception, and Dance was held at the Hotel Astor.

The Business Meeting

The annual business meeting of the Society was held on Wednesday afternoon, with Past-President F. R. Low in the chair.

Of great importance to the entire membership is the annual report of the Council and of its standing committees. The past year has been an especially active one, and it was with considerable interest that the report as presented by Secretary Rice was received.

In his remarks prior to the presentation of the Junior and Student Awards, Dr. Ira N. Hollis, Chairman of the Committee on Awards, urged that the colleges of this country keep before them the opportunities given them by the generosity of members of the Society. The following awards for 1927 were announced:

Junior Award: Wm. M. Frame, Jun. A.S.M.E., Mechanical Engineer, Westinghouse Electric & Mfg. Co., Sharon, Pa., for his paper on "Stresses Occurring in the Walls of an Elliptical Tank Subjected to Low Internal Pressures."

Student Awards: (1) Alfred H. Marshall, Princeton University, Princeton, N. J., for his paper on "Evaporative Cooling;" (2) Roger I. Eby, University of Washington, Seattle, Wash., for his paper on "Measurement of the Angular Velocity of Flywheels."

James D. Cunningham, acting on behalf of the Local Sections Delegates Conference, announced the Nominating Committee for 1928, as follows:

GROUP I—Fred H. Daniels, Worcester, Mass.; Charles R. Main, Boston, Mass., *Alternate.*

GROUP II—James Partington, New York, N. Y.; Howel H. Barnes, Jr., New York, N. Y., *Alternate.*

GROUP III—Charles Schenck, Bethlehem, Pa.; Donald B. Prentice, Easton, Pa., *Alternate.*

GROUP IV—Harry L. Freeman, Birmingham, Ala.; Robert Gregg, Atlanta, Ga., *Alternate.*

GROUP V—John T. Faig, Cincinnati, Ohio.; J. Roland Brown, Cleveland, Ohio, *Alternate.*

GROUP VI—Wilson P. Hunt, Moline, Ill.; Dean E. Foster, Tulsa, Okla., *Alternate.*

GROUP VII—H. L. Doolittle, Los Angeles, Cal.; Wayne A. S. Harmon, Los Angeles, Cal., *Alternate.*

Other business consisted of the reading by title of the Safety Code for Mechanical Power-Transmission Apparatus, and Standards for Cast-Iron Long-Turn Sprinkler Fittings (Screwed and Flanged).

Technical Sessions at Annual Meeting

THE Technical Sessions at the 1927 Annual Meeting were so planned that only two papers or one symposium would be presented at any one session, in order that there might be ample time for their discussion.

The complete papers, with the written and oral discussions and the closures of the authors, will appear in the new quarterly sections of Transactions which will be forthcoming during the year.

Machine Shop Practice Sessions

THIS year the sessions of the Machine Shop Practice Division were held in cooperation with the Machine Tool Congress, which is the technical meeting division of the National Machine Tool Builders' Association. These sessions were widely advertised among machine-tool builders and machine-tool users. This publicity was well justified and the response to it was gratifying. Men prominent in the metal-working industries who are too busy to attend ordinary meetings were very much in evidence at these sessions and they all reported that it was time well spent.

Probably the most sensational of the three sessions was the one devoted to a Symposium on Hydraulic Feeds for Machine Tools. This was held on Tuesday morning, with W. F. Dixon of the Executive Committee of the Machine Shop Practice Division in the chair. Realization of the fundamental importance of hydraulic feed and control for machine tools was driven home to engineers in general by the National Machine Tool Exhibition in Cleveland in September. It is to the credit of the Executive Committee of the Machine Shop Practice Division of the Society that they had sensed the importance of this subject several months before and were therefore ready with a program designed to meet the sudden demand for information which came as an aftermath of the Cleveland Show.

The engineering backgrounds of the speakers at the Hydraulic Feed Session made it possible for them to bring out about all there is in the art up to the present time.

The questions asked and the admissions made indicated that without a doubt builders of every sort of production machine tool are either now experimenting with hydraulic feeds or are getting ready to do so. For the benefit of these machine-tool builders several specialists in oil, in hydraulic pumps, piping and valves and other allied matters told what to expect and what pitfalls to avoid. Other engineers told of the use of hydraulic means for the operation of chucks and other auxiliaries—one in particular describing an ingenious application of a combination of hydraulic and pneumatic pressure by which a low-power pump running constantly was enabled to furnish plenty of power for an intermittent action which momentarily demanded considerable power.

At the close of this meeting the entire audience was alive to the fact that hydraulic feed and control bid fair to have as revolutionary an effect upon the machine-tool industry as did the introduction of high-speed steel by the late Frederick W. Taylor. In fact this session was freely compared to that one of the 1906 Annual Meeting at which Taylor presented his memorable paper upon the "Art of Cutting Metals." It was therefore proposed that here was a subject worthy of the attention of a special committee within the Division, and this proposal will undoubtedly be carried out.

The second session was held in the afternoon, and was given over to a Symposium on Maintenance. The presiding officer was Clayton R. Burt, president of the Machine Tool Congress. The session attracted many who were interested in plant management, as well as builders and users of plant equipment.

When the matter of machine-tool repair came up, some of the machine-tool builders present met the argument for extreme ease of part replacement by bringing out that a reasonable amount of time spent in occasionally replacing a worn or broken part which was a little difficult to reach would amount to less, even in the long run, than the added cost of the machine resulting from making this part very easily replaceable. The main conclusion to be drawn from the papers and discussion at this session is that obsolescence of mechanical equipment is no longer considered simply as a matter of theory, but is recognized in the more progressive manufacturing plants as an important element of efficient management. In such plants the question of whether a machine should be retained is answered by whether it is profitable or not, and this question is in turn settled definitely by cost and performance records properly kept and properly interpreted.

The third session was devoted to the Development of Machine Tools from a User's Viewpoint, and was held Wednesday morning. L. C. Morrow, chairman of the Machine Shop Practice Division, presided and opened the session with the reading of the Progress Report of the Machine Shop Practice Division.

F. C. Spencer, assistant superintendent of manufacturing development, Western Electric Company, Hawthorne Works,

Chicago, was the speaker. He brought out some rather surprising facts about the size of the engineering staff maintained at that plant solely to design special tools and to redesign standard machine tools to their particular needs. Some of these "redesigns" were shown and the reasons for the changes were explained by Mr. Spencer. He suggested that such special redesigning staffs as that of the Western Electric plant could be materially reduced if the machine-tool builders would pay more attention to the users' viewpoint.

This idea was amplified by one of the discussers, who urged that machine-tool builders send their designers to the plants of outstanding machine-tool users so that the designers might be "bitten by production mosquitoes" and thereby infected with "production ideas."

Industrial Power Session

THINKING over the Industrial Power Session leaves one with an appreciation of the versatility of engineers and the breadth of their technical interests when it is remembered that there was an enthusiastic reception of two papers of widely different subject-matter, one a description of the Ruths accumulator, which must have been more or less of a novelty to many or at least a piece of boiler-house equipment with which few had any personal experience, and the other a technical treatment of the deformation of pipe bends.

The session developed a great interest for the average listener through the intelligent guidance which Prof. A. G. Christie, chairman, gave to the discussion. His recent experiences in Great Britain where the accumulator is in use gave him a peculiar fitness to comment on the discussion as it developed. There seemed to be a genuine interest and approval of the accumulator for industrial uses in boiler plants where sudden and frequent peaks in the load create conditions unfavorable for economical operation without some thermal storage device between the boiler and its load. It was, of course, pointed out that there is no new idea involved in the thermal storage principle; but as happens so many times in engineering history, the development of an idea to its economic optimum must wait upon other advances, and particularly upon its thoughtful application to the purpose for which it is best suited.

The return of the problem of the stresses in pipe bends which has engaged the minds of many members of the Society for the past several years came at this meeting through A. M. Wahl, of the Westinghouse Electric and Manufacturing Company, whose interest in this subject was first stimulated because of an assignment of the problem in the student course of study which he was following at East Pittsburgh. The difficulties and perplexities with which this problem is involved were strikingly brought out by the discussion which followed the paper.

Railroad Sessions

AT THE First Railroad Session, held Tuesday morning, with Eliot Summer presiding, three papers and a progress report in Railroad Mechanical Engineering were presented, the papers by Thomas H. Carrow, Thomas C. McBride, and F. J. Scarr, and the report by H. B. Oatley, chairman of the Railroad Division.

In Mr. Carrow's paper the conclusion arrived at was that accident prevention could be reduced to a science and was based on his analysis of the causes of accidents. Wm. Elmer discussed the need of greater safety work in the railroad industry and called attention to the fact that on some roads the rate was about one-third of the average for the country.

Mr. McBride's paper presented data from which he showed that for each locomotive there was a different back pressure at which maximum power could be obtained at lowest cost. E. S. Pearce in the discussion stated that he considered the theoretical soundness of back-pressure regulation as a means of accurate cut-off adjustment had been very definitely established by Mr. McBride. He also stated that the locomotive, which was the productive earning unit of the railroads, was still operated, as far as steam utilization was concerned, by manually controlled rule-of-thumb methods, and that it was not unreasonable to suppose that elimination of the personal equation by mechanical means would be as proportionately economic in this field as it had been in many others. H. B. Oatley, A. I. Lipetz, and W. E. Simons also discussed the paper.

Mr. Scarr's paper presented the economics of handling less-than-carload lots as applied to the railroad and the motor truck, and the use of the container for both. K. J. Ammerman, in discussing the paper, stated as his belief that the further recognition of the motor truck as an ally of the railroad would achieve the returning of much freight now lost by railroads by reducing shipping time through the establishment of freight terminals on the edge of congested areas, enabling freight to be delivered direct from that point. By so doing the time would be cut to a point no overland trucking company could approach.

Engineering is one of the widest fields of human endeavor. This fact was brought home to those who attended the second Railroad Session of the Annual Meeting by the scope of the two papers presented.

The first paper dealt with the Heating and Ventilating of Passenger Cars and the second paper with the Vibration of Bridges. The contrast between the two, both in treatment and subject-matter, at once suggested to the listeners the variety of engineering study. It was interesting to notice that many of the railroad men who discussed the first paper also discussed the second paper with equal intelligence, which indicated that railroad men as a whole have a very good grasp of their subject.

Edward A. Russell presented the first paper and traced the history of the art of heating and ventilating passenger cars from early days to the present time. He pointed out that the pipes and couplings used at the present day were entirely too small for heating long trains, and made this point so well that his own company's automatic vapor system of car heating seemed to be the most logical system for modern use.

In the discussion that followed, J. M. Eaton, of the Molybdenum Corporation, caused the audience to make up their minds to forego electrically fired boilers for train heating for the rest of their lives. He quoted results of a test which showed that the electrically fired boiler took as much power as the hauling of the train required.

The second paper was presented by Dr. S. Timoshenko. He analyzed the problem of vibration of bridges by the methods of advanced analytical mechanics and stressed an aspect of engineering which has been overlooked, namely, the intimate relation between pure theory and the practice which the pure theory makes possible. His paper emphasized the importance of careful track maintenance on railroad bridges, and of careful maintenance of the wheels and balance weights of locomotives, by showing mathematically the effects produced when these things were not in first-rate condition.

First General Session

PROF. W. T. MAGRUDER presided over an exceedingly interesting General Session on Tuesday morning. Tracing the development of the steel-wool industry, Crosby Field described various machines and operations and disclosed history heretofore unknown to the average engineer. The development

in cutting speeds proved startling when one compared the old type of shaving-block machine with the up-to-the-minute equipment demanded by present-day operations and the requirements of industry. The wide varieties of products possible to produce from a wire of given size also proved surprising. Discussion of the paper indicated the possibilities of further elaboration on the problem of cutting speeds, tool shapes, and angles, etc. Additional information on the possible uses of the product seemed desirable, and might appear in a future paper.

Another paper equally as interesting to the average man was that by Karl W. Stinson, on the Modern Fire Engine. The author's description of the older types of equipment brought back many memories of the past, and the statement of the problem of present-day fire fighting, both in the paper and in the discussion, placed before the engineering profession several conditions worthy of attention. Among these, standardization of couplings and even engine capacities were cited as outstanding problems. H. F. J. Porter read from historical notes descriptions of steam engines dating as far back as 1828, when Captain Ericsson designed for experimental purposes a successful pump capable of throwing jets of water varying from one to one and one-quarter inches in diameter to the tops of the highest chimneys.

Joint A.S.M.E.-A.S.R.E. Session

THIS session was opened Tuesday afternoon by W. H. Carrier, president of the American Society of Refrigerating Engineers. Considerable interest was aroused by the first paper, by E. R. Cox, in which a set of general equations involving the film concept of heat transfer and of convenient form for use in the practical design of heat-transfer apparatus appeared. This work was considered by some of those in attendance as marking a new era in the transfer of heat. The real value of the paper seemed to lie in the fact that it gave the reader an idea of the mechanism of heat transfer. It also served as an excellent reminder of the valuable work done by Reynolds in 1874 and Boussinesq in 1901.

Prof. F. G. Hechler, discussing the problem of measuring the heat transmission of walls, argued against the proposal to test complete wall sections in the laboratory and then use these for transmittance to set up tables for standard heat-transmission coefficients. The rational procedure seemed to be to determine the thermal conductivity of the material composing a given wall, and then calculate the transmittance for a complete wall structure analytically by making use of these conductivity values. A series of experiments using heat-flow meters had resulted in valuable data bearing on the question of correlation of laboratory results with the actual performance of walls under service conditions.

Following the presentation of a paper on a comparison of standard flow meters before the 1927 Spring Meeting of the A.S.R.E., the Pennsylvania State College had conducted a series of tests to settle beyond dispute certain matters as to accuracy raised in the discussion of the paper. Prof. A. J. Wood presented the results of these tests which showed that it mattered little whether 12 or 24 pipe diameters preceded or followed the elements, the effect on the venturi and orifice coefficients not being in evidence. It was further shown that the orifice results with a compressible fluid, such as air, up to 11 in. differential, checked well with the results for an incompressible fluid, such as water, indicating the possibility of calibrating an orifice with water.

Hydraulic Session—Symposium on Centrifugal Pumps

THE discussion of the papers which formed the symposium on centrifugal pumps at the Hydraulic Session, at which Geo. A. Orrok acted as chairman, brought out the differences in points of view of the purchaser, the manufacturer, and the consulting engineer. Wm. M. White, of the Allis-Chalmers Co., who led the discussion of the three papers presented, found himself at variance with I. E. Moultrop, of the Edison Electric Illuminating Co. of Boston, who took manufacturers of centrifugal pumps to task for not furnishing proper performance test data and for throwing on the purchaser the necessity of performing his own tests in order to determine the characteristics of the pump. Part of the blame was laid by the manufacturers upon methods of purchase which had an eye to the lowest quotation and upon the tacit acceptance by the purchaser in the majority of cases of the pump as delivered to him without any effort to determine if what he had purchased was what he had specified. F. W. Dean, of Boston, took the middle course of the consulting engineer, saying that he would not expect to purchase equipment for a client without making a test of it, and that he would not expect the manufacturer to make this test, pointing out the practice of central stations in testing their boilers as a precedent for the same procedure with centrifugal pumps.

It was unfortunate that two of the authors were prevented from presenting their papers in person. Mr. Davey's residence in England and Mr. Aisenstein's residence in California accounted for their absence. Prof. Elmer G. Hooper of New York University had made a very careful study of the paper by Davey and presented a lucid abstract of it. The author of the third paper, Joseph Lichtenstein, of the Bethlehem Shipbuilding Co., Elizabeth, N. J., and formerly with Brown-Boveri, convincingly defended the rather technical analytical methods given in his paper as being necessary in a modern engineering design, and quite in keeping with advances in other branches of the profession.

Session on Photography

THE important part played in our industrial life by photography was ably set forth by three speakers in the Photography Session on Wednesday morning. Dr. W. E. Forsythe, president of the Optical Society of America, presided.

C. E. K. Mees dealt with the problem from the standpoint of the engineer or physicist who wishes to study over long periods phenomena which occur too rapidly to be observed leisurely. For instance, the astronomer photographs the heavens and studies the picture under the most favorable conditions. High-speed motion-picture photography permits the accurate determination of effects of explosives and offers evidence of the types best suited for certain conditions. The reverse of the process, that is, retardation, enables one to study growing plants, or to observe the action of bacterial growths, crystal formation, etc.

Discussing the subject Photomicrography and Its Application to Mechanical Engineering, F. F. Lucas said that one of the great difficulties, the production of clear-cut images at high magnifications, is being overcome through the use of ultra-violet rays. Magnifications of 3500 diameters are common with this method. A valuable application is in the study of the effects of certain hardening treatments as applied to metals. Some indication of the future may be found in the speaker's statements showing that through the extension of the field of high magnification, we are learning more about what exists in the "no man's land" between the crystalline structure revealed by high magnification and the atomic structure which it is now possible to examine by means of the X-ray.

Continuing the story into the realm of the atom, Dr. Wheeler P. Davey introduced the X-ray as a tool of considerable usefulness to the mechanical engineer, not only in explaining facts

previously known, but also in clarifying knowledge of structural materials, thus paving the way for the development of still additional materials to meet new requirements. The discussion of the action of the atoms of two metals in combination proved most interesting, and offered an explanation of the action of certain alloys during machining and rolling operations. The present trend, it developed, is to extend investigations toward the realm of the electron, the effort being to get at the theory of things to be able to predict how to make a new and better type of structural materials.

Fuels Session

IT IS NEVER difficult to get an audience at a meeting of the Fuels Division, nor to start a discussion. The room is always filled to capacity and the chairman never has to appeal to the audience to contribute. In spite of the fact that this year's program contained but one paper in addition to the progress report of the division which was so ably presented by Prof. J. T. Ward of M.I.T., there was no lack of material to talk about.

In the discussion which centered around the paper on the K.S.G. Process of Low-Temperature Carbonization, by Walter Runge, vice-president of the International Coal Carbonization Co., of New York, there were the usual representatives of the conservative and progressive points of view. The familiar worry about the possibility of disposing of the by-products from a carbonization process was expressed by several speakers and confidently disposed of by the author. There was also the misunderstanding about the purpose for which the process described was specifically designed, and the confusion of the process and what was claimed for it with other processes and other claims. There was, in fact, much more of opinion than of fact in much of the discussion.

Statements which were made about the relative costs and merits of different types of domestic fuels were also seed for discussion and disagreement, and led to the time-honored misunderstandings about the Government estimates of fuel resources which a most careful statement and explanation by H. W. Brooks, formerly of the Bureau of Mines, failed to clarify in the minds of some.

W. L. Abbott, past-president of the Society and chief operating engineer of the Commonwealth Edison Co., Chicago, presented the central-station point of view and offered financial reward to the engineer who would solve with the economic success he demanded the problem of the dual utilization of coal by the electric and gas companies. Mr. Runge took considerable pains to point out the differences between the plant in Milwaukee operating on the McEwen-Runge process and the one at New Brunswick, N. J., operating on the K.S.G. process, the former designed to provide a fuel for a central station and the latter to provide a domestic fuel, and promised operating data on both plants when such became available.

Materials-Handling Session

TWO papers were presented at this session, namely, "Materials Handling as an Aid to Production," by Frank L. Eidmann, and "Operating Costs of Electric Industrial Trucks and Tractors," by C. B. Crockett and H. J. Payne.

Wm. F. Hunt in a discussion of Mr. Eidmann's paper considered that a very important fact had been brought to the foreground in that the cost of handling material was an item in unit costs which needed and should receive increasing attention from the manager. F. G. Raymant called special attention to the satisfactory results of shipping in standard-size bundles which facilitated handling and were a source of profits to all concerned. A. L. Lewis saw an increased demand for efficiency in management, and no greater opportunity to bring about savings than by a reduction in the present cost of materials handling.

Messrs. Crockett and Payne's paper showed how direct and indirect costs might be classified and estimated, and how the methods it described might be applied in the operation of electric trucks. H. V. Coes in discussing the paper suggested that more attention should be given to maintenance costs, as he had found them too high.

Session on Education and Training for the Industries of Non-College Type

THIS session, on Wednesday afternoon, presided over by Prof. D. C. Jackson, from the standpoint of discussion proved to be one of the most interesting of the entire meeting. One outstanding impression gained from the discussion of the paper by C. J. Freund was that a draftsman would do better work as a result of shop training, for he would have a working knowledge of the manner in which the work he expected to design would be handled in the shop and the shop man would be more likely to respect him. Others felt that to help the man at the board would be but to help him off the board; in other words, making a good draftsman of him would merely convince him that he was too good for the job. It also seemed very desirable to impress upon the young draftsman the fact that his was not a job of making mere drawings, but rather one of creation, and that the drawing was but a small part of the work.

The various steps in an apprentice-training program, costs, forms of cooperative courses, and the selection of teaching personnel formed the subject-matter of a paper by Ben. S. Moffatt. A very important point to be considered, as developed by both the author and those who discussed the paper, was the manner in which the student was led through the course. It was possible, it was pointed out, to entirely defeat the purpose of the training course if insufficient attention was given to this matter. It was advocated that the course be revised at frequent intervals to incorporate new ideas as they developed. The problem of expense seemed to be pretty generally recognized as a bugbear, and one suggested remedy was to merge a goodly portion of it into the plant "overhead" by using the employed personnel for apprenticeship training to the greatest possible extent.

Steam Tables Research Session

THERE is more real intellectual pleasure to be derived from a meeting of the Steam Tables Research Committee than from any other meeting of the Society, and appreciation of this fact is seen in the attendance at this year's session. It proved to be the best of all so far in point of significance, as was brought out by Dr. Davis who stressed the historical importance of the information made public by the various investigators. It was, as some one put it, the occasion of the most important announcements of researches on steam since the days of Regnault.

These announcements, which will be more carefully presented in due course of time, were made by the various investigators, Dr. Osborne of the Bureau of Standards, Dr. Smith of M.I.T., and Dr. Davis of Harvard, and by Messrs. J. H. Keenan and E. L. Robinson of the General Electric Co., Schenectady, N. Y., who are correlating the data furnished by the investigators and applying it to the formation of new steam tables and studying the effects of the new values on the reheat factors of steam turbines. Dr. Osborne reported tests made with the calorimeter which has interested his audiences of previous years by

reason of its beautiful workmanship and careful design. Incidental to the tests was the necessity for a determination of the mechanical equivalent of heat, and an announcement of its mean value along the atmospheric path was made. Mr. Keenan reported that the values furnished by the researches made by Drs. Keyes and Smith at M.I.T. were being used as a basis for an extension of the Mollier diagram presented to the Society two years ago to regions above 800 deg. fahr., and that there was a satisfactory agreement of the data with those furnished by Dr. Davis which are the basis of the diagram.

Dr. Davis's discussion of his work in checking the calculations which he and Keenan had made in order to produce the Mollier diagram was vivid with the flashes of his wit and intellect; a heady stimulant.

Prior to the presentation of the technical reports, a report of the Executive Committee of the Steam Table Fund was made by Geo. A. Orrok, chairman of that committee.

Central-Station Power Session

THE Central-Station Power Session on Thursday morning lived up to the traditions of a large audience and much vigorous discussion. Charles M. Schwab, President of the Society, opened the meeting by making an informal address, after which the chairman, E. B. Ricketts, of the N. Y. Edison Co., called upon W. L. Abbott, Past-President of the Society, who had been invited to the platform by Mr. Schwab.

Large boilers and furnaces, pulverized-fuel firing, water-cooled furnace walls, and high capacities were among the impressions formed by the discussion of two papers, one by E. J. Bailey, president of the Fuller-Lehigh Co., Fullerton, Pa., and the other by Henry Kreisinger, of the Combustion Engineering Co., and T. E. Purcell, of the Duquesne Light Co., Pittsburgh, Pa. The first paper described several modern boiler plants and the second gave operating data on six other plants.

The term "per cent of rating" received some well-deserved criticism from W. A. Shoudy, of Columbia University, New York. It developed that such terms are not easily changed; but it would seem that a group which can so glibly adopt Professor Wohlenberg's "fraction cold" should be capable of framing an adequate substitute for "per cent of rating."

Development in the central-station field is so rapid that yesterday's novelties are the commonplace practices of today. Not many years ago, at a meeting devoted largely to stokers, some one induced John Anderson to talk about powdered coal. This year all of the plants described were burning powdered coal, and J. G. Worker, of the American Engineering Co., Philadelphia, Pa., deemed it advisable to come to the defense of the stoker.

Management Sessions

THE Management Sessions were held this year under the joint auspices of the Management Division, A.S.M.E., and the American Management Association. The first session was on Thursday morning, with Charles Piez, chairman of the board, Link-Belt Company, Chicago, Ill., presiding. The opening remarks at this Session were made by Charles M. Schwab, retiring President of the A.S.M.E.

Following Mr. Schwab's brief address, Charles W. Lytle, chairman of the Management Division presented an abstract of the Progress Report of the Division. The first paper at this session was on Control of Factory Overhead, by H. G. Perkins of The Murray Corporation of America, Detroit, Mich. The second paper was devoted to Production Control in a Wrought Brass Mill. It was prepared by W. R. Clark and Arthur Brewer, who are respectively general works managers and manager of the Mill Production Division of the Bridgeport Brass Company.

In the beginning the discussion was in the nature of questions as to the application of overhead and production control in various kinds of businesses. It then swung over to the question of budgets—rather warm arguments pro and con being developed. A rather amusing example of the fear of an unusual name for a familiar thing was cited by one of the discussers. He said that at one time he approached the manager of a company with which he was connected with the idea of putting in a budget. The manager turned this plan down with considerable heat. About a week later he again approached this manager to ask if an estimate of expenditures might be made and this was immediately and cheerfully allowed. So this concern worked under an "estimate of expenditures" for several years.

The second Management Session was held in the afternoon of the same day. Frank L. Sweetser, president of the American Management Association, presided. This session was given over to the subject of budgets and methods of applying them in industrial managment. The first paper, on Budgetary Control, was presented by J. P. Jordan, consulting industrial engineer and member of the firm of Stevenson, Harrison & Jordan, New York City. The second was upon Some Essential Principles for Budgetary Control, by H. V. Coes, vice-president and general manager of the Belden Manufacturing Company, Chicago.

Mr. Jordan stressed the desirable effect of budgetary control upon the morale of any organization—when proper advantage is taken of its possibilities in this direction. The American business man as a lover of sports reacts favorably to a sporting proposition in business, and that is exactly what budgetary control can bring out. With a par value set there is a goal either to be approached or even surpassed, and as a result there is a general "keying up" effect throughout the organization. This was a decidedly inspirational paper.

Mr. Coes' paper went more into details of the setting up and working of budgets, and was illustrated by several slides showing actual office forms with typical entries. This paper may well be called a complete condensed treatise upon budgetary control and it is easily conceivable that it could be used as the basis for devising and putting into operation such a system under almost any circumstances.

One of the interesting features of this session was Mr. Coes' response to a request for information about the budgetary control of the A.S.M.E. As a vice-president of the Society and chairman of the Finance Committee, Mr. Coes has been very close to the setting up and operation of the A.S.M.E. budget. His explanation of its set-up and functioning showed that it had much to do with the present smooth running of the manifold activities of the Society, and that instead of hindering the progress of any department it had a decided effect toward inspiring keener interest and setting higher ideals for attainment.

Second General Session

THREE papers were presented at the Second General session on Thursday morning, presided over by Dean Arthur M. Greene, Jr.

The first paper, "Analysis of Strains and Stresses in a Wristpin," by Guy B. Collier, was presented by title. The work showed an application of the mechanical theory of elasticity to strains and stresses in the wristpin of an automobile engine, and showed that the pins could be made considerably lighter than those of present-day practice and still have the requisite strength.

Dr. S. A. Moss gave a brief résumé of various items of a satisfactory set-up for laboratory flow measurements, as developed at the Thomson Research Laboratory of the General Electric Company at Lynn, Mass. It developed that experiments had confirmed the choice of the nozzle with rounded approach for the measurement of air and gas. For measuring the nozzle pressure, the impact tube had proved most satisfactory, and the position had been found to be of no great importance, so long as it did not disturb the jet.

In the last paper of the session, John L. Cox gave the particulars and results of tests of a representative portion of one section of the Big Creek Power Plant No. 2 of the Southern California Edison Co., the object of which was to determine the elastic limit and ultimate strength, as well as deformation and behavior under high pressure. The test specimen, a forging over 13 ft. in length and about 66 in. in inside diameter, reached its elastic limit at a pressure of 2150 lb. per sq. in., corresponding to a tangential stress of 25,000 lb. per sq. in. in the steel walls, the measured proportional limit of the steel at the ends being 24,500 lb. The pipe failed at a pressure of 5300 lb., corresponding to a fiber stress of 62,000 lb. per sq. in., compared with an actual tensile strength of 67,750 lb. The external expansion was 6 in. in diameter, and the internal expansion 6$^3/_8$ in. in diameter. It appeared that an internal pressure producing a calculated stress practically equal to the proportional limit of its metal could be withstood without permanent deformation by a seamless forged-steel pipe; and that it might fail at about the pressure given by the Birnie formula arbitrarily extended to the ultimate strength.

Session on Oil and Gas Power

E. J. KATES presided over the Oil and Gas Power Session on Thursday afternoon, at which papers on Efficiencies of Otto and Diesel Engines, and Diesel Engines for Locomotives were presented.

In the former the authors gave in the form of curves and tables the results of calculations for ideal Otto and Diesel engines in which the working substance is a mixture of real gases. It seemed very desirable to Prof. F. O. Ellenwood, who presented the paper, that in speaking of the performance of an internal-combustion motor the words "engine efficiency" be used generally. Those discussing the paper seemed to feel that the authors had performed a worthy act in calling attention to the need for a standard basis of comparison in the internal-combustion field. It appeared that there might be considerable argument in favor of the use of an air-cycle standard which is different both from the cold-air cycle, adopted generally up to the present time, and also from the hot-air standard proposed in the paper.

The second paper, presented by R. Hildebrand, proposed improvements in cylinders of steam locomotives so that they might be used either as steam or Diesel cylinders or as both simultaneously, retaining the advantages of both. The practicability of the locomotive, as it appeared to some of the discussers, seemed to depend upon whether or not the increased weight of machinery would permit sufficient boiler capacity to meet the heavy requirements of starting, when the Diesel power would be at its minimum.

Following the papers the Rudolph Diesel Award for the best paper delivered during Oil and Gas Power Week, 1927, was presented to William F. Joachim for his contribution on Oil-Spray Investigations of the N.A.C.A., read at the Oil-Power Conference held at Pennsylvania State College, April 21 to 23, 1927. The Award was received by Prof. F. G. Hechler of Pennsylvania State College in the absence of Mr. Joachim.

Boiler Feedwater Session

AT THE boiler feedwater session of a year ago, which was the first held at an annual meeting of the Society, there were more present than the room provided could hold. That the much larger room used this year was well filled at all times is striking evidence of the great interest which is being taken in the work of the committees. The activities of the session consisted in the reading of progress reports of most of the committees, preceded by the presentation by S. T. Powell, chairman of the Joint Research Committee on Boiler-Feedwater Studies, of the report of the executive committee. Announcement was made of the decision to undertake the financing of a research fund of $300,000 over a period of five years to provide for the work of some of the committees.

Considerable interest was developed in the problem of foaming and priming, which is being studied by Sub-Committee No. 3, of which C. W. Foulk is chairman. Professor Foulk presented a theory to account for the mechanism of foaming, and also excerpts of the reports of tests which have been recently conducted to study the behavior of waters which were foaming.

The great number of railroad men present and the testimony which they presented to the meeting in discussing their problems was evidence of the variety and the importance of the problems which faced them.

An interesting discussion of the problem of standardizing the sampling of streams was presented by Norman F. Prince, of the Rochester Gas and Electric Corp., and Isador W. Mendelsohn, of the U. S. Public Health Service, Chicago, Ill., described several sampling devices which were in use by the Government. This problem of sampling is being considered by the Committee with a view to standardizing the technique and the apparatus used.

Research Session

THERE is still much to be learned about lubrication. This seemed to be the conclusion reached by the speakers and discussers at the Symposium on Lubrication held Thursday afternoon. Three research papers were presented—"Viscosity of Lubricants Under Pressure," by M. D. Hersey and Henry Shore; "The Effect of Running In on Journal-Bearing Performance," by S. A. McKee; and "An Investigation of the Performance of Waste-Packed Armature Bearings," by G. B. Karelitz.

The joint discussion which followed the presentation of these papers showed a widespread interest in the subject of lubrication and was ably spurred on by Prof. O. W. Boston, the presiding officer of this session. Mr. Karelitz's remarks that the qualities of oil and of waste were steadily getting worse and worse drew considerable fire from manufacturers of oil and waste. H. B. Fitch, of the New Haven lines, caused much merriment and evoked a good deal of sympathy by describing the difficulties which the employees of his company have in packing the rather poorly designed bearings with which the cars of his company are equipped. He expressed the wish that the bearings might be designed so that it would not be necessary for one to stand on one's head while packing them. Another point emphasized in this discussion was that of safety for research workers. Those occupied with research problems were urged to make sure that material and funds were available for protection of the research worker while experimenting in new fields. It was pointed out that the expenditure of a few dollars would suffice to protect research workers in dangerous experiments such as determining the behavior of lubricants under high pressure.

At the end of the meeting the progress report of the Special Committee on Lubrication was presented by A. E. Flowers.

MECHANICAL ENGINEERING

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British and American Engineers

O wad some Pow'r the giftie gie us,
Ta see oursels as others see us;
It wad frae mony a blunder free us
And foolish notion.

A FASCINATING series of articles entitled "An American Diary" has appeared during the last few months in *The Engineer*, London, written by its able editor, Mr. Loughnan Pendred, who visited this country last spring. He comments on certain of the American plants where he visited, the men that he met, and the impressions of our engineering developments which he received.

These articles present a picture of our developments as seen by a keen and gifted observer and give us appraisal of ourselves as we appear in his eyes. One admires his delightful style, his analytical point of view, and that typically British attitude of critical inquiry. We may feel that at times he does not give us full credit for our accomplishments, or possibly that he does not use the correct yardstick in making his comparisons. But Mr. Pendred has at least given us an opportunity to see ourselves as others see us, and let us hope that we may benefit from this appraisal.

The last article is one of the most interesting of the series. In it, Mr. Pendred compares American and British engineers and engineering. He believes that American engineers are more daring than British engineers. Also that they dare to do things because the financial rewards for success are so great in our large and rapidly developing country. This may be true in a measure. On the other hand, the Parsons turbine and the tank for war service were developments by British engineers quite as daring in many ways as our American achievements. Are Americans really more daring or are they less conservative than British engineers? For instance, welding is little used for construction purposes in Great Britain, though widely adopted here. Possibly it is less a matter of the size of the reward than a question of initiative. British engineers are more restrained by considerations of past practice and by trade restrictions than are American. Excellent as is the technical training of our British cousins, one sometimes doubts the wisdom of requiring all their young engineers to serve a long term in the works where they lose much of their initiative by absorbing the ideas of restrictions of machines and processes that fellow-workmen believe are fixed and inviolable. American engineers, free in a greater measure from such influences, have untrammeled judgment and will try out a new idea either in design or production when it seems reasonably certain that it will work.

In America engineering enjoys more freedom from governmental interference than in Britain. Would our electrical industry have grown so rapidly had municipal ownership prevailed here as in Britain? British municipal plants show little evidence of aggressive "Power Sales Engineers" to develop markets for electricity and gas. American ideas of "Service" lead to well-developed cooperative plans which achieve results and gain the good-will of the public. In Britain one finds more individualism among engineers. Hence there are few large engineering organizations in that country who design, construct, and operate works or utilities. As a result of this individualism one finds much variety in their plant equipment, which in some ways is an advantage. This individualism has led many British engineers to turn their attention to the development and marketing of inventions and patents.

In Britain, family influence and seniority are often leading factors in securing engineering positions and promotion. In America the profession is less crowded, and advancement is made on merit. This has been a powerful incentive to our ambitious workers to put forth their best efforts.

Regarding labor, is it "splendid self-denial" on the part of British labor to restrict individual output, or, is it national economic suicide? America believes that the New Industrial Day demands maximum output to secure the lowest possible costs—which will lead to greater consumption of goods—and employs machinery wherever possible to achieve this result. Would the development of more "Company Spirit" in British workmen lead to better work, greater output, and more satisfaction in life? Does the industrial engineer have his proper part in the planning and operation of British industries?

Individually, British engineers are splendid fellows. Their university training is excellent. British workmen are better-trained mechanics on the average than American. Britain could learn much from America in regard to production, and co-operation of management and men. American engineers would gain by obtaining that broader cultural training of the British and by acquiring their inquisitive attitude toward technical matters which leads to original thinking and the development of new ideas. Closer acquaintance of the engineers of the two nations and free interchange of ideas would be a liberal education to both sides. We shall cordially welcome any British fellow-engineers who may follow Mr. Pendred in paying us a visit. American engineers always receive a hearty welcome on the other side. Both nations will benefit immeasurably by such intercourse and better understanding—at least these are the ideas of a Canadian who has had opportunities to observe both American and British engineers and engineering.

ALEXANDER GRAHAM CHRISTIE.[1]

[1] Professor of Mechanical Engineering, Johns Hopkins University, Baltimore, Md. Vice-President A.S.M.E.

The Annual Meeting

THOSE who are in the stream of Society meetings seek ways of differentiating one meeting from another or of measuring the advance of the profession or its science. To such, the last annual meeting offered a few startling revelations. They are set down here in undigested form as "thought detonations."

First—Offhand but confident talk at the Steam Power Session of boilers capable of generating one million pounds of steam per hour.

Second—The statement at the Steam Tables Research Session that more information about the properties of high-pressure steam was presented at that session than has ever been released before.

Third—Dr. Wickenden's program of a relationship between the engineering profession and education which should have a far-reaching effect on the profession.

Fourth—Three splendid sessions on various phases of machine-shop practice dealing with immediate pressing problems. The success of these sessions points the way for future constructive activities in this field.

Fifth—The presidential address on Human Engineering which stated that forward-looking management views industry as a cooperative undertaking and that conflict between capital and labor is unnecessary.

The efforts of over fifty authors and many more discussers cannot be summarized in a few paragraphs or a few pages, and the selection of a few random points may be unfair to the majority. But the 1927 meeting goes into the record as a great event in which hundreds of engineers made a successful advance step for their profession and its science.

"The Moods of Mechanism"

IN THE October *Harpers*, William McFee tells an interesting story under the title, "Moods of Mechanism." He is exceptionally prepared to tell this story, for he is a retired marine engineer of long and varied experience, and is also a writer of great power and charm, with many novels and essays to his credit.

Passing over the pyschoanalysis of the introduction and admitting the resemblance between the behavior of human beings and machines, we come to the old war between the man who designs machines and the man who operates them. Each often thinks the other is a fool, and sometimes both are right. In an ideal world a young man contemplating engineering as a profession should spend one lifetime operating machines and then, in a reincarnation, with full memory of the past experience, he should spend another lifetime designing machines that would give no operating engineer a moment's anxiety. This is obviously an unattainable ideal; but under conditions as they are, it would seem wise for the designer to acquire all the operating experience possible and to get acquainted with operating men and listen to their statements with care and patience.

In machines as in the organic world there is a process of evolution; no machine springs full-armed from the brain of even Mr. McFee's trinity of genius, Stevenson, Watt, and Diesel. Think of the profound astonishment that would result if Stevenson could see a modern high-powered locomotive; if Watt could see a modern mammoth turbine; if Diesel could read in a recent newspaper this: "The White Star Line, it is announced, has placed an order for the construction, in a Belfast shipyard, of a giant motorship which will be even larger than the *Majestic*, at present the biggest ship afloat. It will be nearly 1000 feet long and will be driven by internal-combustion engines of the Diesel type."

Mr. McFee probably realizes that when he was struggling manfully with the temperamental Bolinder semi-Diesel engine in the launch towing mahogany logs, he was helping to find out and eliminate things that must not be used on Diesel engines, and hence he became a factor in machine evolution.

I read with great delight Mr. McFee's descriptions of desperate struggles with totally depraved machines whose continued running alone could prevent disaster. I remember a certain anxious hour some forty years ago when an unwilling steam engine had to be kept running to drive a foundry fan until the last of the molten iron could be drawn off and the cupola bottom dropped. Even today I feel the intense relief that came over me when the foundryman came to the engineroom door and waved his hand, and I shut the throttle valve.

Delightful also is Mr. McFee's description of his stormy voyage on the *Fernfield*, with engines by Blair of Stockton-on-Tees, when a corroded drain plug dropped out into the sea and let a two-inch stream of water into the ship.

After the strenuous years at sea Mr. McFee must now enjoy his literary work amid the quiet comforts of his Westport home where the typewriter is the only temperamental machine in sight; but I wonder if at times he does not sigh for the days of action when he faced disaster with an oil can, a wrench, and a stout heart.

A. W. SMITH.[1]

Metamorphosis

THE country has just witnessed an exceedingly interesting metamorphosis, which has been the cause of world-wide editorial comment.

The approaching quantity production of the new Ford car is a striking illustration of the unprecedented growth of wealth and volume of business in the United States during the last twenty years. In 1907 a momentous gathering took place in Mr. J. P. Morgan's library on Madison avenue in New York City. Banks were failing, business was crumbling all over the country, legal-tender money had suddenly disappeared, and an economic calamity of a magnitude sufficient to shake the world was impending. The representatives of the nation's biggest financial institutions were gathered there—Geo. F. Baker of the First National Bank, Jas. A. Stillman of the National City Bank, with Mr. Morgan at the head of the table, and in the pocket of the latter lay the assurance from the United States Treasury Department that the Federal Government was also ready to come to the relief of the country's business and banking. Finally a scheme was evolved and the panic subsided on Mr. Morgan's announcement that $25,000,000 was available to be used as loans to credit institutions in distress.

Twenty-five millions was a big sum in those days, and the country's welfare depended on someone's ability to provide this amount. Today, one man alone, Mr. Henry Ford, controlling the Ford Motor Company, could write a check for that amount without causing anything more than a slight ripple in his cash account. In fact, Mr. Ford has spent four times as much, $100,000,000, to put his new car into production, and has done it all out of his cash reserves, without any financing and with no more publicity as far as the financing operation was concerned than any reader would experience in cashing a small check at his bank—and the Ford Motor Company is not the only concern that could do it. Hence events which were apt to become major causes of a panic of national scope twenty years ago could be satisfactorily handled today without producing more than a local disturbance, and it is only such world-wide disturbances as were, for example,

[1] Dean Emeritus, Sibley College, Cornell University. Mem. A.S.M.E.

created by post-war deflation that can cause industrial collapse of the kind with which this country had to deal in 1921.

There is another aspect of the new Ford car situation of interest to mechanical engineers. Some ten years ago it was only the special racing cars and a few of the most expensive cars that could be operated at a mile-a-minute speed. All the other cars either did not have power enough to develop such a speed or would have shaken themselves to pieces in a couple of hours of riding. Ten years ago only the most expensive alloys and the biggest engines could be used to attain this speed, and even then the phantom of vibration threatened success. Such has been the advance of engineering in the field of alloys, gasoline-engine design, and particularly in the comprehension of causes and remedies for vibration, that today it has become possible to build for a price less than $500 a car that will make 60 m.p.h. without shaking the passengers to pieces and without flying off the road. That this is possible only through the enormous resources of the Ford Motor Co. is a contributary cause to the same effect and takes substantially nothing from this really spectacular achievement of American automobile engineering.

The old, old question is, of course, brought up by what has been said before. Rudyard Kipling's engineer MacAndrew was the first to ask it in verse. The question is, now that we have the machine, what about the man? Now since every one who can draw from his bank, beg, borrow, or steal $500 or less can have a 60 m.p.h. car, what will happen to traffic? Maximum speed limits have been raised in most of the states to the level of 35 or 40 m.p.h. Knowing human nature in general, and its American variety in particular, one may safely predict that to the new Ford owner the 35 or 40 m.p.h. limit will become the lower limit of speed when no officer is in sight. In one way it is perfectly reasonable to say that to a skilled driver under present traffic conditions in general a speed of 35 or 40 m.p.h. is really safer than 20 or 25. To a driver who lacks skill and the necessary physical qualifications, even a speed of 20 m.p.h. is dangerous today when a man must be capable of stopping, slowing down, accelerating, or wiggling out of the way at a split second's notice. At the same time there are a vast number of drivers who belong neither to one nor the other of the above two categories and who are just in between. They can get there without killing themselves or their fellow-citizens, if neither they nor the latter try to do so too fast. What the result will be on the performance of this in-between class of drivers when eight thousand 60 m.p.h. cars begin to roll off from the Ford assembly lines every 24 hours is something which will be very interesting to observe.

Cooperative Industrial Research

RECENTLY in closing an address before the National Research Council, Dr. A. D. Little made the following statement: "Our prosperity in the past has been largely based on cheap land and superabundant raw materials. Today our civilization has developed such complexity that we cannot hope to maintain our position except through the assistance which only science can afford."

Where science has revealed new possibilities of great promise for industrial development, such as in the fields of the chemical, electrical, and automotive industries, research has been generously supported. There are, however, a number of industrial leaders to the need of research as an instrument in the necessary development. Invention gave us aniline dyes, electric power and light, the steam turbine, wireless telegraphy, and nickel steel; but it took research, and millions of dollars, to give us fast colors, the argon-filled tungsten bulb, high-pressure turbines of 200,000 horsepower, household receiving sets, and the alloy steels in automobiles.

It is difficult to give accurate figures on research expenditures in the United States. According to information recently collected by the National Industrial Conference Board, incidental to a study of industrial organization, about $200,000 000 is spent annually by corporations and the Government for industrial research. Industries whose research expenditures were largest five years ago are those which have scored the greatest relative growth since then. So rapid has been the extension of the research method that whereas in 1921 only 578 companies were known to maintain research departments or laboratories, more than 1000 concerns have organized research divisions in operation at the present time.

There are certain classes of research, however, that are not as yet adequately supported although of great importance. One of these is fundamental research, which does not so readily offer to the business intelligence of industry an immediate profitable return. This fact is similarly true of many problems in applied research which are so broad in their application that no single industry feels justified in supplying the funds which should come from all those that would ultimately benefit. Here the national engineering societies can be helpful, and industry is showing a growing inclination to seek their unbiased assistance on such problems.

In this connection it will be well for us to give consideration to the following statement recently made by Past-President Charles M. Schwab:

> The tremendous importance of research to the industry of our nation has been clearly demonstrated during and since the Great War. In the present huge annual expenditures for industrial research we have convincing proof of the growing appreciation of its essential nature in providing the path for improvement in all arts and sciences. In the infancy of an industry and the engineering that guides its problems simple and individual initiative and ingenuity are the chief requisites of success. But as an art grows and expands its requirements become complex to the point where research is essential to further development.
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> While every progressive industry is today rapidly applying the searching scrutiny of science to its individual methods, there is a phase of research the importance of which is not yet fully realized. I refer to that form of cooperative industrial research which the great national engineering societies are in a unique position to promote. They represent a medium for effective service of which industry should avail itself.

Junior Education for Engineering Activities

MEMBERS of the Society have shown great interest in the investigation of engineering education that has been carried on for some years under the auspices of the Society for the Promotion of Engineering Education by Dr. W. E. Wickenden. A second parallel investigation under Dr. Wickenden has just been announced, the funds for which have been provided by the Carnegie Corporation and certain educational institutions. The new inquiry is intended to indicate the character and the extent of the need in the United States for a type of technological education that differs from the programs of the engineering colleges by being briefer, more intensive, and more direct in method, less theoretical and more strictly technical in content, and not leading to an academic degree.

Attention will be directed in this investigation to a type of education rather than a type of institution. Many agencies now have some share in this form of education, and the inquiry will seek to ascertain what their contributions are and how fully they meet the general need.

Dr. Wickenden states that it is recognized that the field of specific training for crafts, trades, and industrial processes, not commonly classed as forms of engineering activity, is one of great magnitude, but that it warrants separate investigation under other auspices.

From this statement it appears that the new investigation, while of great interest and importance to our Society, is not intended to touch the major portion of the field of education and training for the industries, but is limited to a particular field of education.

"Mechanical Engineering" in a New Form

WE HOPE that our new cover appeals to the membership as much as it does to the Committee on Publications and the staff. It has been designed by Walter D. Teague. We have thought that nothing more fitting could be used on this cover than the drawing of the Library Building for the University of Louvain, to be dedicated in 1928 and to replace the building destroyed in the World War. It will include as a memorial to American engineers who died overseas in the World War a clock and carillon for the tower, to be given by engineering societies in the United States. The names of all American engineers who gave their lives in service of their country or its allies at home or overseas, so far as they can be learned, will be suitably recorded in the new library.

Beginning with this issue the Society's new publication policy, decided on last May, goes into effect. Within the next three months the first sections of Transactions, which will henceforth appear in pamphlet form with a type page the size of that used in this issue of MECHANICAL ENGINEERING, will be ready for distribution. This size, it will be recalled, was adopted because of its greater convenience for filing.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Books Reviewed in This Department Are Purchasable Through the A.S.M.E.

FROM time to time there undoubtedly appears in this department a review or notice of a new technical book that engages your interest. You wish to purchase the book, but find that you local bookseller has either not yet stocked it or does not handle such works. In all probability it will require from ten days to two weeks for him to secure a copy for you.

You can obviate this delay by purchasing the book through the Society. Barring certain exceptions, such as books of foreign publishers, your order will be filled on the day it is received. *There will be no extra charge for this service.* You merely send your order to the A.S.M.E. Publication-Sales Department, and the book, together with a bill at the publisher's price, will be mailed to you. If desired, the price will be charged to your account.

The Faith of a Physicist

THE NEW REFORMATION. From Physical to Spiritual Realities. By Michael I. Pupin, of Columbia University. Charles Scribner's Sons, New York, 1927. $2.50.

REVIEWED BY EDWIN E. SLOSSON[1]

THIS volume of Professor Pupin's must not be confounded with the common run of books on religion and science, now so numerous and so frequently either intolerant attacks on the opposite side of the controversy or else specious pleas for reconciliation by arguing that "two truths can never conflict" and that therefore the cosmical conceptions of the ancient Hebrews can be made to harmonize with current views of scientists, by doing a bit of budging on both sides. Professor Pupin is above such sectarianism as well as above such superficialities.

[1] Director of Science Service, Washington, D. C.

"The New Reformation" reveals still more clearly the characteristics that made his "From Immigrant to Inventor" the delight of readers of all classes. In Professor Pupin we find an intellect of the keenest and a training of the most technical combined with a deep personal piety, free from dogmatism or intolerance, and an esthetic sensitiveness so wide as to appreciate equally the beauty of natural objects and of natural law. Another rare quality is an almost religious reverence for the great leaders of scientific progress, such as leads him to suggest setting aside certain holidays dedicated to these "Saints of Science."

The heroes he treats most enthusiastically and sympathetically in this volume are Galileo, Newton, Faraday, Carnot, Maxwell, Tyndall, and Gibbs. Einstein and his successors he never mentions, notwithstanding the intimate bearing of their theories on the questions he discusses.

Step by step he traces the history of physical science and shows how man by means of his machines, such as the steam engine and the voltaic cell, is enabled to convert non-coordinated and chaotic motion into coordinated, purposive, and useful action. When we enter the world of plants and animals we find more abundant evidence of Creative Coordination, and this finally is the guiding power which is bringing the discordant human granules into a social cosmos.

The quotation of three paragraphs from "The New Reformation" will show the trend of his crowning argument and its triumphant conclusion.

> Just as electrical radiation reveals the existence of an ultra-maferial entity, the electrical flux, so the psychic realities of our consciousness reveal the existence of an ultra-material entity, the soul. The ultimate natures of these two entities are hidden behind a cosmic veil which so far has remained impenetrable; their manifestations, however, are perfectly clear; they are like a living embroidery of supremely subtle texture adorning the visible face of the cosmic veil.
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> Newton, Faraday, Maxwell, Ampère, and many other great scientists believed strongly in spiritual realities. Have they been led